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Selected Values of Chemical Thermodynamic Properties

Tables for the First Thirty-Four Elements In the Standard Order of Arrangement

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

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NBS TECHNICAL NOTE 270-3

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Selected Values of Chemical Thermodynamic Properties

Tables for the First Thirty-Four Elements in the Standard Order of Arrangement

D. D. Wagman, W. H. Evans, V. B. Parker,
I. Halow, S. M. Bailey, and R. H. Schumm

Institute for Basic Standards
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Washington, D.C. 20234

[This Technical Note supersedes Technical Notes 270-1 and 270-2]

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PREFACE

Technical Note 270-3 is the third in a series of publications containing material prepared as a revision of the tables of Series I of National Bureau of Standards Circular 500, Selected Values of Chemical Thermodynamic Properties, by F. D. Rossini, D. D. Wagman, W. H. Evans, S. Levine, and I. Jaffe. This Note extends the revision to Tables 23, 33, and 34, covering the compounds of the elements carbon, zinc, and cadmium in the Standard Order of Arrangement. In addition this Note contains all of the Tables of Technical Note 270-1 and 270-2, including corrections for a number of minor errors. Thus this Note supersedes Technical Notes 270-1 and 270-2.

Donald D. Wagman, Chief,
Thermochemistry Section.

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SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES

by

Donald D. Wagman, William H. Evans, Vivian B. Parker,
Iva Halow, Sylvia M. Bailey, and Richard H. Schumm

INTRODUCTION

Substances and Properties Included in the Tables

The tables contain values where known of the enthalpy and Gibbs energy of formation, enthalpy, entropy and heat capacity at 298.15°K (25°C), and the enthalpy of formation at 0°K, for all inorganic substances and organic molecules containing not more than two carbon atoms. In some instances such as metal-organic compounds, data are given for substances in which each organic radical contains one or two carbon atoms.

No values are given in these tables for metal alloys or other solid solutions, fused salts, or for substances of undefined chemical composition.

Physical States

The physical state of each substance is indicated in the column headed "State" as crystalline solid (c), liquid (liq), glassy or amorphous (amorp), or gaseous (g). Solutions in water are listed as aqueous (aq). For non-aqueous systems the physical state is that normal for the indicated solvent at 298.15°K.

Definition of Symbols

The symbols used in these tables are defined as follows: P = pressure; V = volume; T = absolute temperature; E = intrinsic or internal energy; S = entropy; H = E + PV = enthalpy (heat content); G = H - TS = Gibbs energy (formerly the free energy); $C_p = (dH/dT)_P$ = heat capacity at constant pressure.

Conventions Regarding Pure Substances

The values of the thermodynamic properties of the pure substances given in these tables are for the substances in their standard states (indicated by the superscript ° on the thermodynamic symbol). These standard states are defined as follows:

For a pure solid or liquid, the standard state is the substance in the condensed phase under a pressure of one atmosphere.

For a gas the standard state is the hypothetical ideal gas at unit fugacity, in which state the enthalpy is that of the real gas at the same temperature and at zero pressure.

The values of $\Delta Hf°$ and $\Delta Gf°$ given in the tables represent the change in the appropriate thermodynamic quantity when one gram-formula weight of the substance in its standard state is formed, isothermally at the indicated temperature, from the elements, each in its appropriate standard reference state. The standard reference state at 25 °C for each element except phosphorus has been chosen to be the standard state that is thermodynamically stable at 25 °C and at one atmosphere pressure. For phosphorus the standard reference state is the crystalline white form; the more stable forms have not been well characterized thermochemically. The same reference states have been maintained for the elements at 0 °K except for the liquid elements bromine and mercury, for which the reference states have been chosen as the stable crystalline forms. The standard reference states are indicated in the tables by the fact that the values of $\Delta Hf°$ and $\Delta Gf°$ are exactly zero.

The values of $H^\circ_{298} - H^\circ_0$ represent the enthalpy difference for the given substance between 298.15 °K and 0 °K. If the indicated standard state at 25 °C is the gas, the corresponding state at 0 °K is the hypothetical ideal gas; if the state at 25 °C is solid or liquid, the corresponding state at 0 °K is the thermodynamically stable crystalline solid, unless otherwise specifically indicated.

The values of S° represent the virtual or "thermal" entropy of the substance in the standard state at 298.15 °K, omitting contributions from nuclear spins. Isotope mixing effects, etc., are also excluded except in the case of the hydrogen-deuterium (^1H-^2H) system. Where data have been available only for a particular isotope, they have been corrected when possible to the normal isotopic composition.

The values of the enthalpies of formation of gaseous ionic species are computed on the convention that the value of $\Delta Hf°$ for the electron is zero. Conversions between 0 and 298.15 °K are calculated using the value of $H^\circ_{298} - H^\circ_0$ = 1.481 kcal per mole of electrons, and assuming that the values of $H^\circ_{298} - H^\circ_0$ for the ionized and un-ionized molecules are the same.

Conventions Regarding Solutions

Solutions in water are designated as aqueous (aq); other solvents are designated by name or chemical formula. The concentration of the solution is expressed in terms of the number of moles of solvent associated with one mole of the solute. If no concentration is indicated, the solution is assumed to be "dilute".

The standard state for a solute in aqueous solution is taken as the hypothetical ideal solution of unit molality (indicated as "std. state, m = 1"). In this state the partial molal enthalpy and heat capacity of the solute are the same as in the infinitely dilute real solution. For non-aqueous solutions the standard state of the solute is the hypothetical ideal solution of unit mole fraction of solute ("std. state, $x_2 = 1$").

The value of $\Delta Hf°$ given in the tables for a solute in its standard state is the apparent molal enthalpy of formation of the substance in the infinitely dilute real solution. At this dilution the partial molal enthalpy is equal to the apparent molal quantity. At concentrations other than the standard state, the value of $\Delta Hf°$ represents the apparent enthalpy of the reaction of formation of the solution from the elements comprising the solute, each in its standard reference state, and the appropriate total number of moles of solvent. In this representation the value of $\Delta Hf°$ for the solvent is not required. The experimental value for a heat of dilution is obtained directly as the difference between the two values of $\Delta Hf°$ at the corresponding concentrations.

The values of the thermodynamic properties tabulated for the individual ions in aqueous solution are based on the usual convention that the values of $\Delta Hf°$, $\Delta Gf°$, $S°$ and $C_p°$ for H^+ (aq, std. state, m = 1) are zero. The properties of a neutral electrolyte in aqueous solution in the standard state are equal to the algebraic sum of these values for the appropriate kinds and number of individual ions assumed to constitute the molecule of the given electrolyte. When the undissociated species, rather than the sum of the ions, is meant, the notation "undissociated" or "un-ionized" is used. For an ionic species the properties tabulated refer to that undissociated ion. By adopting the above convention with respect to aqueous H^+, it follows that the thermodynamic relation $\Delta Gf° = \Delta Hf° - T\,\Delta Sf°$ will not hold for an individual ionic species. However no problem arises when neutral chemical systems are considered.

Unit of Energy and Fundamental Constants

All of the energy values given in these tables are expressed in terms of the thermochemical calorie. This unit, defined as equal to 4.1840 joules, is generally accepted for the presentation of chemical thermodynamic data. Values reported in other units have been converted to calories by means of the conversion factors for molecular energy given in Table A.

The following values of the fundamental physical constants have been used in these calculations:

R = gas constant = 8.3143 ± 0.0012 J/deg mol = 1.98717 ± 0.00029 cal/deg mol

F = Faraday constant = 96487.0 ± 1.6 coulombs/mol = 23060.9 ± 0.4 cal/volt equivalent

Z = Nhc = 11.96258 ± 0.00107 J/cm^{-1} mol = 2.85912 ± 0.00026 cal/cm^{-1} mol

c_2 = second radiation constant = hc/k = 1.43879 ± 0.00015 cm deg

0°C = 273.15°K

These constants are consistent with those given in the Table of General Physical Constants, recommended by the National Academy of Sciences - National Research Council[1]. The formula weights in the tables have been calculated for the molecular formula given in the Formula and Description column using the 1961 Table of Relative Atomic Weights based on the atomic mass of ^{12}C = 12 exactly[2].

Internal Consistency of the Tables

All of the values given in these tables have been calculated from the original articles, using consistent values for all subsidiary and auxiliary quantities. The original data were corrected where possible for differences in energy units, molecular weights, temperature scales, etc. Thus we have sought to maintain a uniform scale of energies for all the substances in the tables. In addition the tabulated values of the properties of a substance satisfy all the known physical and thermodynamic relationships among these properties. The quantities $\Delta Hf°$, $\Delta Gf°$, and S° at 298.15°K satisfy the relation:

$$\Delta Gf° = \Delta Hf° - T \Delta Sf°.$$

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[1] NBS Technical News Bulletin, October 1963.

[2] A. E. Cameron and E. Wichers, J. Am. Chem. Soc. 84, 4192 (1962).

Furthermore the calculated value of any thermodynamic quantity for a reaction is independent of the path chosen for the evaluation.

In some cases newer data may have become available on certain substances after the values were selected for these tables. Because of the need to maintain the internal consistency of the tables, it is not always possible to incorporate these newer data into the tables without a detailed analysis of the effect of such a change. Unless great care is used, relatively significant errors in calculated values of $\Delta H°$ or $\Delta G°$ for specific reactions may result from the introduction of such data.

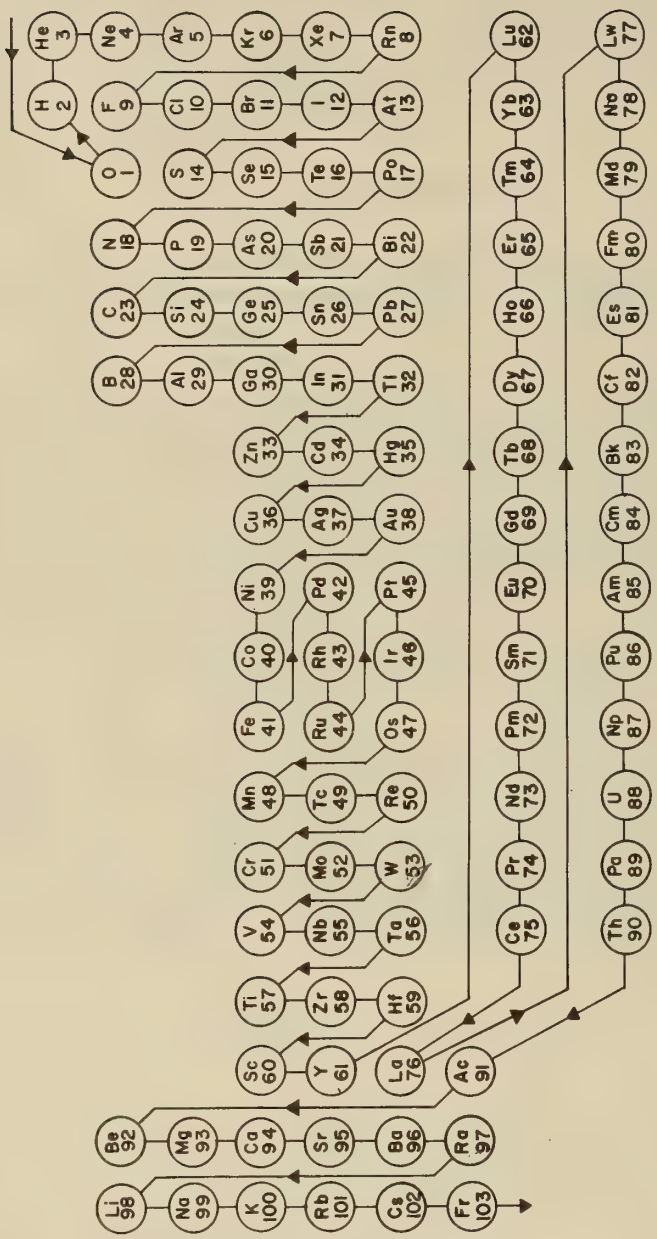
Uncertainties

The uncertainty in any value in the tables depends on the uncertainties of all the determinations in the total chain of reactions used to establish the value.

A discussion of the uncertainties will be included in the final publication of these tables in the National Standard Reference Data System. However we have followed certain rules with respect to significant figures to indicate these uncertainties. Values are tabulated in general such that the overall uncertainty lies between 2 and 20 units of the last figure. On the other hand, values are given so that the experimental data from which they are derived may be recovered with an accuracy equal to that of the original quantities. Thus the number of significant figures for any one value in the tables need not represent the absolute accuracy of that value. For solutions of varying composition values are frequently tabulated to more figures to make possible the recovery of enthalpies of solution and dilution. Similarly values of ΔHf_0° and $\Delta Hf_{298.15}^\circ$ may be given to different numbers of significant figures. In this instance the quantity with the lesser number of figures is used to represent the uncertainty estimate. The larger number of figures is used for the other quantity to retain the significance of the temperature correction term.

Arrangement of the Tables

The compounds in the tables are entered according to the Standard Order of Arrangement, (see Figure 1), by the principle of latest position. In this scheme, a compound is listed under the element occurring latest in the list; water of hydration is neglected. Within a given element-table will be found all of the compounds of that element with elements occurring earlier in the order; the arrangement within a table follows the same ordering. An exception occurs in the carbon tables (Table 23), which is divided into subgroups consisting of all compounds with one carbon atom, then all with two carbon atoms, etc.



Standard Order of Arrangement of the Elements and Compounds based on the Periodic Classification of the Elements

Figure 1.

TABLE A

CONVERSION FACTORS FOR UNITS OF MOLECULAR ENERGY

	J/mol	cal/mol	cm^3 atm/mol	kWh/mol	Btu/lb-mol	cm^{-1}/molecule	eV/molecule
1 J/mol =	1	2.390057×10^{-1}	9.86923	2.77778×10^{-7}	0.429923	8.35940×10^{-2}	1.036409×10^{-5}
1 cal/mol =	4.18400	1	41.2929	1.162222×10^{-6}	1.798796	3.49757×10^{-1}	4.33634×10^{-5}
1 cm^3 atm/mol =	0.1013250	2.42173×10^{-2}	1	2.81458×10^{-8}	4.35619×10^{-2}	8.47016×10^{-3}	1.050141×10^{-6}
1 kWh/mol =	3,600,000	860,421	3.55292×10^{7}	1	1,547,721	300,938	37.3107
1 Btu/lb-mol =	2.32600	5.55927×10^{-1}	22.9558	6.46111×10^{-7}	1	1.944396×10^{-1}	2.41069×10^{-5}
1 cm^{-1}/molecule =	11.96258	2.85912	118.0614	3.32294×10^{-6}	5.14299	1	1.239812×10^{-4}
1 eV/molecule =	96487.0	23060.9	952,252	2.68019×10^{-2}	41482.0	8065.73	1

The underlined numbers represent the fundamental values used in deriving this table. The remaining factors were obtained by applying the relationships:

$$n_{ij} = n_{ik} \cdot n_{kj} \qquad n_{ii} = n_{ik} \cdot n_{ki} = 1$$

TABLES OF SELECTED VALUES OF PROPERTIES

SERIES I

Enthalpy of Formation at 0°K

Enthalpy of Formation at 298.15°K

Gibbs Energy of Formation at 298.15°K

Enthalpy at 298.15°K

Entropy at 298.15°K

Heat Capacity at 298.15°K

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 1(1) OXYGEN

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
O	g	15.9994	58.983	59.553	55.389	1.607	38.467	5.237
O^+	g		373.019	375.070				
O^{2+}	g		1183.73	1187.26				
O^{3+}	g		2450.87	2455.88				
O^{4+}	g		4236.1	4242.6				
O^{5+}	g		6862.8	6870.8				
O^{6+}	g		10048.	10057.				
O^{7+}	g		27097.	27106.				
O^{8+}	g		47191.	47203.				
O^-	g		25.20	24.29				
O_2	g	31.9988	0	0	0	2.0746	49.003	7.016
std. state, m = 1	aq			-2.8	3.9		26.5	
O_2^+	g		280.0	281.48				
O_3	g	47.9982	34.74	34.1	39.0	2.4736	57.08	9.37
	aq			30.1				

Table 2(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

HYDROGEN

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	$C_p{}^\circ$
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
H	g	1.0080	51.626	52.095	48.581	1.481	27.391	4.9679
^1H	g	1.0078	51.626	52.095	48.580	1.481	27.391	4.9679
^2H	g	2.0141	52.524	52.981	49.360	1.481	29.455	4.9679
H^+	g	1.0080	365.211	367.161				
std. state, m = 1	aq			0	0		0	0
H^-	g		34.40	33.39				
H_2	g	2.0159	0	0	0	2.0238	31.208	6.889
$^1H_2$	g	2.0156	0	0	0	2.0238	31.208	6.889
$^2H_2$	g	4.0282	0	0	0	2.0481	34.620	6.978
$^1H^2H$	g	3.0219	0.079	0.076	- 0.350	2.0328	34.343	6.978
H_2 std. state, m = 1	aq	2.0159		-1.0	4.2		13.8	
H_2^+	g		355.74	357.23				
OH	g	17.0074	9.25	9.31	8.18	2.1070	43.890	7.143
O^2H	g	18.0135	8.72	8.81	7.76	2.1509	45.321	7.140
OH^+	g	17.0074	316.	317.5				
OH^-	g		-32.3	-33.67				
std. state, m = 1	aq			-54.970	-37.594		-2.57	-35.5
HO_2	g	33.0068	6.	5.				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 2(2) HYDROGEN

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
HO_2^+	g		272.	271.				
HO_2^- std. state, m = 1	aq			-38.32	-16.1		5.7	
H_2O	liq	18.0153		-68.315	-56.687		16.71	17.995
^2H_2O	liq	20.0276		-70.411	-58.195		18.15	20.16
$^1H^2HO$	liq	19.0213		-69.285	-57.817		18.95	
H_2O	g	18.0153	-57.102	-57.796	-54.634	2.3667	45.104	8.025
^1H_2O	g	18.0150	-57.102	-57.796	-54.634	2.3667	45.103	8.025
^2H_2O	g	20.0276	-58.855	-59.560	-56.059	2.3801	47.378	8.19
$^1H^2HO$	g	19.0213	-57.927	-58.628	-55.719	2.3721	47.658	8.08
H_2O^+	g	18.0153	233.5	234.3				
H_2O_2	liq	34.0147		-44.88	-28.78		26.2	21.3
	g		-31.08	-32.58	-25.24	2.594	55.6	10.3
undissoc.; std. state, m = 1	aq			-45.69	-32.05		34.4	
in 0.1 H_2O	aq			-44.965				
0.5 H_2O	aq			-45.198				
1 H_2O	aq			-45.365				
2 H_2O	aq			-45.520				
3 H_2O	aq			-45.585				
4 H_2O	aq			-45.620				

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Table 2(3) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

HYDROGEN

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
H_2O_2 in 5 H_2O	aq			-45.638				
10 H_2O	aq			-45.670				
15 H_2O	aq			-45.681				
20 H_2O	aq			-45.685				
50 H_2O	aq			-45.687				
∞ H_2O	aq			-45.69				
$H_2O_2^+$	g		220.7	220.7				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 3(1) HELIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
He	g	4.0026	0	0	0	1.481	30.1244	4.9679
std. state, m = 1	aq			-0.4	4.6		13.3	
He^+	g		566.978	568.459				

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Table 4(1) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — NEON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Ne	g	20.183	0	0	0	1.481	34.9471	4.9679
std. state, m = 1	aq			-1.1	4.6		15.8	
Ne^+	g		497.29	498.77				
Ne^{2+}	g		1444.7	1447.6				
Ne^{3+}	g		2915.	2919.				
Ne^{4+}	g		5156.	5162.				
Ne^{5+}	g		8072.	8079.				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 5(1) ARGON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Ar	g	39.948	0	0	0	1.481	36.9822	4.9679
std. state, m = 1	aq			-2.9	3.9		14.2	
Ar^{+}	g		363.42	364.90				
Ar^{2+}	g		1000.5	1003.5				
Ar^{3+}	g		1943.9	1948.3				
Ar^{4+}	g		3323.	3329.				
Ar^{5+}	g		5053.	5060.				
Ar^{6+}	g		7159.	7168.				
Ar^{7+}	g		10019.	10029.				
Ar^{8+}	g		13328.	13340.				

Table 6(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

KRYPTON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Kr	g	83.80	0	0	0	1.481	39.1905	4.9679
std. state, m = 1	aq			-3.7	3.6		14.7	
Kr^+	g		322.84	324.32				
Kr^{2+}	g		889.47	892.43				
Kr^{3+}	g		1741.6	1746.0				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 7(1) XENON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Xe	g	131.30	0	0	0	1.481	40.5290	4.9679
std. state, m = 1	aq			-4.2	3.2		15.7	
Xe^{+}	g		279.72	281.20				
Xe^{2+}	g		768.8	771.8				
Xe^{3+}	g		1509.6	1514.1				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 8(1) RADON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Rn	g	222.	0	0	0	1.481	42.09	4.968
Rn^+	g		247.86	249.34				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 9(1) FLUORINE

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
F	g	18.9984	18.38	18.88	14.80	1.558	37.917	5.436
F^+	g		420.16	422.14				
F^{2+}	g		1226.98	1230.44				
F^{3+}	g		2672.0	2676.9				
F^{4+}	g		4684.2	4690.6				
F^{5+}	g		7318.7	7326.6				
F^{6+}	g		10942.9	10952.3				
F^{7+}	g		15213.4	15224.2				
F^{8+}	g		37209.	37222.				
F^-	g		-63.7	-64.7				
std. state, m = 1	aq			-79.50	-66.64		-3.3	-25.5
F_2	g	37.9968	0	0	0	2.108	48.44	7.48
F_2^+	g		365.1	366.6				
FO	g	34.9978	41.	41.				
F_2O	g	53.9962	-4.7	-5.2	-1.1	2.604	59.11	10.35
F_2O^+	g		310.	311.				
F_2O_2	g	69.9956		4.3				
F_2O_3	g	85.9950		3.8				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 9(2) FLUORINE

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
HF	liq	20.0064		71.65			18.02+x	12.35
	g		-64.789	-64.8	-65.3	2.055	41.508	6.963
undissoc.; std. state, m = 1	aq			-76.50	-70.95		21.2	
ionized; std. state, m = 1	aq			-79.50	-66.64		-3.3	-25.5
in 2 H_2O	aq			-75.79				
3 H_2O	aq			-75.98				
4 H_2O	aq			-76.10				
5 H_2O	aq			-76.165				
10 H_2O	aq			-76.235				
15 H_2O	aq			-76.273				
25 H_2O	aq			-76.292				
30 H_2O	aq			-76.300				
40 H_2O	aq			-76.308				
50 H_2O	aq			-76.316				
75 H_2O	aq			-76.333				
100 H_2O	aq			-76.340				
200 H_2O	aq			-76.358				
300 H_2O	aq			-76.374				
400 H_2O	aq			-76.403				
500 H_2O	aq			-76.423				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 9(3) FLUORINE

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
HF in 600 H_2O	aq			-76.443				
700 H_2O	aq			-76.463				
800 H_2O	aq			-76.485				
900 H_2O	aq			-76.511				
1,000 H_2O	aq			-76.531				
2,000 H_2O	aq			-76.80				
3,000 H_2O	aq			-76.95				
4,000 H_2O	aq			-77.05				
5,000 H_2O	aq			-77.14				
7,000 H_2O	aq			-77.25				
10,000 H_2O	aq			-77.37				
20,000 H_2O	aq			-77.70				
∞ H_2O	aq			-79.50				
HF_2^- std. state, m = 1	aq	39.0048		-155.34	-138.18		22.1	
XeF_4	c	207.294		-62.5				

Table 10(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CHLORINE

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Cl	g	35.453	28.68	29.082	25.262	1.499	39.457	5.220
Cl^+	g		328.86	330.74				
Cl^{2+}	g		877.81	881.17				
Cl^{3+}	g		1798.26	1803.10				
Cl^{4+}	g		3031.0	3037.3				
Cl^{5+}	g		4594.9	4602.7				
Cl^{6+}	g		6825.	6835.				
Cl^{7+}	g		9461.	9472.				
Cl^{8+}	g		17495.	17508.				
Cl^{9+}	g		26739.	26753.				
Cl^{10+}	g		37241.	37257.				
Cl^-	g		-57.7	-58.8				
std. state, m = 1	aq			-39.952	-31.372		13.5	-32.6
Cl_2	g	70.906	0	0	0	2.193	53.288	8.104
std. state, m = 1	aq			-5.6	1.65		29.	
in CCl_4; std. state, $x_2 = 1$				-4.44	1.09		34.7	
Cl_2^+	g		264.8	266.3				
Cl_2^{2+}	g		752.	755.				
Cl_3^- std. state, m = 1	aq	106.359			-20.			
ClO	g	51.4524	24.36	24.34	23.45	2.114	54.14	7.52

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 10(2) CHLORINE

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
ClO^- std. state, m = 1	aq			-25.6	-8.8		10.	
ClO_2	g	67.4518	25.09	24.5	28.8	2.580	61.36	10.03
std. state, m = 1	aq			17.9	28.1		41.4	
ClO_2^- std. state, m = 1	aq			-15.9	4.1		24.2	
ClO_3	g	83.4512		37.				
ClO_3^- std. state, m = 1	aq			-23.7	-0.8		38.8	
ClO_4^- std. state, m = 1	aq	99.4506		-30.91	-2.06		43.5	
Cl_2O	g	86.9054	19.71	19.2	23.4	2.719	63.60	10.85
in CCl_4; std. state, $x_2 = 1$				12.62	22.98		43.0	
Cl_2O_7	liq	182.9018		56.9				
	g			65.0				
HCl	g	36.4610	-22.020	-22.062	-22.777	2.066	44.646	6.96
std state, m = 1	aq			-39.952	-31.372		13.5	-32.6
in 1 H_2O	aq			-29.05				
1.5 H_2O	aq			-31.71				
2 H_2O	aq			-33.69				
2.5 H_2O	aq			-34.77				
3 H_2O	aq			-35.49				
4 H_2O	aq			-36.548				
4.5 H_2O	aq			-36.927				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 10(3) CHLORINE

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
HCl in 5 H_2O	aq			-37.231				
6 H_2O	aq			-37.687				
8 H_2O	aq			-38.242				
10 H_2O	aq			-38.556				
12 H_2O	aq			-38.762				
15 H_2O	aq			-38.964				
20 H_2O	aq			-39 160				
25 H_2O	aq			-39.278				
30 H_2O	aq			-39.357				
40 H_2O	aq			-39.459				
50 H_2O	aq			-39.521				
75 H_2O	aq			-39.609				
100 H_2O	aq			-39.657				
150 H_2O	aq			-39.700				
200 H_2O	aq			-39.740				
300 H_2O	aq			-39.776				
400 H_2O	aq			-39.796				
500 H_2O	aq			-39.812				
600 H_2O	aq			-39.823				
700 H_2O	aq			-39.832				

Table 10(4) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CHLORINE

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
HCl in 800 H_2O	aq			-39.839				
900 H_2O	aq			-39.845				
1,000 H_2O	aq			-39.850				
1,500 H_2O	aq			-39.867				
2,000 H_2O	aq			-39.878				
3,000 H_2O	aq			-39.892				
4,000 H_2O	aq			-39.898				
5,000 H_2O	aq			-39.905				
7,000 H_2O	aq			-39.912				
10,000 H_2O	aq			-39.918				
20,000 H_2O	aq			-39.927				
50,000 H_2O	aq			-39.936				
100,000 H_2O	aq			-39.942				
∞ H_2O	aq			-39.952				
in CCl_4; std. state, $x_2 = 1$				-24.7	-20.3		27.5	
$CHCl_3$; std. state, $x_2 = 1$				-25.1	-20.5		26.8	
HClO	g	52.4604				2.440	56.54	8.88
undissoc.; std. state, m = 1	aq			-28.9	-19.1		34.	

Table 10(5) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CHLORINE

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
HClO in 6 H_2O	aq			-28.42				
7 H_2O	aq			-28.48				
8 H_2O	aq			-28.54				
10 H_2O	aq			-28.62				
12 H_2O	aq			-28.66				
15 H_2O	aq			-28.72				
20 H_2O	aq			-28.77				
25 H_2O	aq			-28.8				
30 H_2O	aq			-28.82				
40 H_2O	aq			-28.85				
50 H_2O	aq			-28.87				
75 H_2O	aq			-28.89				
100 H_2O	aq			-28.90				
200 H_2O	aq			-28.92				
300 H_2O	aq			-28.92				
500 H_2O	aq			-28.92				
1,000 H_2O	aq			-28.93				
$HClO_2$ undissoc.; std. state, m = 1	aq	68.4598		-12.4	1.4		45.0	
$HClO_3$ std. state, m = 1	aq	84.4592		-23.7	-0.8		38.8	
$HClO_4$	liq	100.4586		- 9.70				
std. state, m = 1	aq			-30.91	-2.06		43.5	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 10(6) CHLORINE

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$HClO_4$ in 2 H_2O	aq			-25.40				
2.5 H_2O	aq			-26.90				
3 H_2O	aq			-28.02				
4 H_2O	aq			-29.33				
4.5 H_2O	aq			-29.76				
5 H_2O	aq			-30.17				
6 H_2O	aq			-30.55				
8 H_2O	aq			-30.90				
10 H_2O	aq			-31.02				
12 H_2O	aq			-31.07				
15 H_2O	aq			-31.10				
20 H_2O	aq			-31.08				
25 H_2O	aq			-31.06				
30 H_2O	aq			-31.04				
40 H_2O	aq			-30.99				
50 H_2O	aq			-30.96				
75 H_2O	aq			-30.91				
100 H_2O	aq			-30.89				
200 H_2O	aq			-30.85				
500 H_2O	aq			-30.84				

Table 10(7) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CHLORINE

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$HClO_4$ in 1,000 H_2O	aq			-30.84				
3,000 H_2O	aq			-30.85				
7,000 H_2O	aq			-30.86				
10,000 H_2O	aq			-30.87				
20,000 H_2O	aq			-30.88				
100,000 H_2O	aq			-30.89				
∞ H_2O	aq			-30.91				
$HClO_4 \cdot H_2O$	c	118.4739		-91.35				
$HClO_4 \cdot 2H_2O$	liq	136.4892		-162.04				
ClF	g	54.4514	-13.0	-13.02	-13.37	2.127	52.05	7.66
ClF_3	liq	92.4482		-45.3				
	g		-38.0	-39.0	-29.4	3.262	67.28	15.26
ClF_3^+	g		262.0	262.5				
$(ClF_3)_2$	g	184.8964		-81.1	-56.7		117.	
ClO_3F	g	102.4496	-3.6	-5.7	11.5	3.179	66.65	15.52
$ClF_3 \cdot HF$	g	112.4546		-107.7	-91.8		86.	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 11(1) BROMINE

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Br	g	79.909	28.189	26.741	19.701	1.481	41.805	4.968
Br^+	g		301.38	301.41				
Br^{2+}	g		799.2	800.7				
Br^{3+}	g		1627.0	1630.0				
Br^{4+}	g		2785.	2789.				
Br^-	g		-53.0	-55.9				
std. state, m = 1	aq			-29.05	-24.85		19.7	-33.9
Br_2	c	159.818	0					
	liq			0	0	5.859	36.384	18.090
	g		10.923	7.387	0.751	2.323	58.641	8.61
std. state, m = 1	aq			-0.62	0.94		31.2	
in CCl_4; std. state, $x_2 = 1$				0.71	0.36		37.6	
n-C_7F_{16}; std. state, $x_2 = 1$				3.9	-1.8		55.4	
CS_2				0.01				
CH_3COOH				-0.25				
$CHCl_3$				0.65				
Br_2^+	g		255.6	253.5				
Br_3^- std. state, m = 1	aq	239.727		-31.17	-25.59		51.5	
Br_5^- std. state, m = 1	aq	399.545		-34.0	-24.8		75.7	
BrO	g	95.9084	31.9	30.06	25.87	2.13	56.75	7.67

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 11(2) BROMINE

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
BrO^- std. state, m = 1	aq	95.9084		-22.5	-8.0		10.	
BrO_2	c	111.9078		11.6				
BrO_3^- std. state, m = 1	aq	127.9072		-20.0	0.4		39.0	
HBr	g	80.9170	6.826	-8.70	-12.77	2.067	47.463	6.965
std. state, m = 1	aq			-29.05	-24.85		19.7	-33.9
in 1 H_2O	aq			-17.38				
1.5 H_2O	aq			-20.52				
2 H_2O	aq			-22.40				
2.5 H_2O	aq			-23.75				
3 H_2O	aq			-24.68				
4 H_2O	aq			-25.961				
4.5 H_2O	aq			-26.395				
5 H_2O	aq			-26.706				
6 H_2O	aq			-27.147				
8 H_2O	aq			-27.649				
10 H_2O	aq			-27.953				
12 H_2O	aq			-28.139				
15 H_2O	aq			-28.307				
20 H_2O	aq			-28.460				
25 H_2O	aq			-28.540				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 11(3) BROMINE

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
HBr in 30 H_2O	aq			-28.595				
40 H_2O	aq			-28.671				
50 H_2O	aq			-28.719				
75 H_2O	aq			-28.780				
100 H_2O	aq			-28.815				
150 H_2O	aq			-28.853				
200 H_2O	aq			-28.874				
300 H_2O	aq			-28.900				
400 H_2O	aq			-28.915				
500 H_2O	aq			-28.926				
600 H_2O	aq			-28.935				
700 H_2O	aq			-28.942				
800 H_2O	aq			-28.948				
900 H_2O	aq			-28.953				
1,000 H_2O	aq			-28.958				
1,500 H_2O	aq			-28.973				
2,000 H_2O	aq			-28.982				
3,000 H_2O	aq			-28.994				
4,000 H_2O	aq			-29.001				
5,000 H_2O	aq			-29.006				
7.000 H_2O	aq			-29.013				

Table 11(4) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

BROMINE

Substance				ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
HBr	10,000 H_2O	aq			-29.019				
	20,000 H_2O	aq			-29.028				
	50,000 H_2O	aq			-29.037				
	100,000 H_2O	aq			-29.041				
	∞ H_2O	aq			-29.05				
	in CCl_4; std. state, $x_2 = 1$				-11.9	-10.9		30.4	
	$CHCl_3$; std. state, $x_2 = 1$				-12.0	-11.0		30.4	
	n-C_4H_{10}; std. state, $x_2 = 1$				-11.8	-10.7		30.2	
	C_6H_6; std. state, $x_2 = 1$				-12.9	-11.2		28.1	
	n-C_6H_{14}; std. state, $x_2 = 1$				-11.4	-10.9		32.1	
	n-C_8H_{18}; std. state, $x_2 = 1$				-11.4	-11.0		32.5	
	n-$C_{10}H_{22}$; std. state, $x_2 = 1$				-11.3	-11.1		33.0	
HBr^+		g		261.1	260.7				
HBrO	undissoc.; std. state, m = 1	aq	96.9164		-27.0	-19.7		34.	
$HBrO_3$	std. state, m = 1	aq	128.9152		-20.0	0.4		39.0	
	in 400 H_2O	aq			-19.94				
BrF		g	98.9074	-20.6	-22.43	-26.09	2.156	54.70	7.88
BrF_3		liq	136.9042		-71.9	-57.5		42.6	29.78
		g		-58.41	-61.09	-54.84	3.416	69.89	15.92
BrF_5		liq	174.9010		-109.6	-84.1		53.8	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 11(5) BROMINE

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
BrF_5	g		-98.75	-102.5	-83.8	14.452	76.50	23.81
BrCl	g	115.362	5.28	3.50	-0.23	2.245	57.36	8.36
in CCl_4				-1.547				
$BrCl^+$	g		261.3	261.0				
Br_2Cl^- std. state, m = 1	aq	195.271		-40.7	-30.7		45.1	

Table 12(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

IODINE

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
I	g	126.9044	25.631	25.535	16.798	1.481	43.184	4.968
I^+	g		266.77	268.16				
I^{2+}	g		707.22	710.09				
I^-	g		-45.4	-47.0				
std. state, m = 1	aq			-13.19	-12.33		26.6	-34.0
I_2	c	253.8088	0	0	0	3.154	27.757	13.011
	g		15.659	14.923	4.627	2.418	62.28	8.82
std. state, m = 1	aq			5.4	3.92		32.8	
in CCl_4; std. state, m = 1				6.0	2.66		39.0	
C_6H_6; std. state, $x_2 = 1$				4.3	1.7		36.5	
C_6H_{12}; std. state, $x_2 = 1$				5.8	2.8		37.8	
C_7F_{16}; std. state, $x_2 = 1$				10.3	5.1		45.2	
$CF_3C_6F_{11}$ (perfluoromethylcyclohexane); std. state, $x_2 = 1$				9.5	5.0		42.9	
CCl_2FClF_2; std. state, $x_2 = 1$				7.3	3.6		40.2	
$CHBr_3$; std. state, x = 1				5.3	1.6		40.3	
C_6H_5Cl				4.8				
$C_6H_5CH_3$				3.8				

Table 12(2) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

IODINE

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
I_2 in $C_6H_5COOCH_3$				3.9				
CH_3COOCH_3				2.4				
$CH_3COOC_2H_5$				3.1				
CH_3OH				2.1				
1,4 dioxane				1.8				
$(C_2H_5)_2O$				1.8				
$C_6H_5NO_2$				1.7				
C_2H_5OH				1.7				
pyridine				4.0				
CS_2				5.2				
$CHCl_3$				5.3				
I_2^+	g		230.5	231.2				
I_3^- std. state, m = 1	aq	380.7132		-12.3	-12.3		57.2	
IO	g	142.9038	42.3	41.84	35.80	2.153	58.65	7.86
IO^- std. state, m = 1	aq			-25.7	-9.2		-1.3	
IO_3^- std. state, m = 1	aq	174.9026		-52.9	-30.6		28.3	
IO_4^-	aq	190.9020		-35.2				
I_2O^{2-} std. state, m = 1	aq	269.8082			-19.7			
I_2O_5	c	333.8058		-37.78				
HI	g	127.9124	6.850	6.33	0.41	2.069	49.351	6.969
std. state, m = 1	aq			-13.19	-12.33		26.6	-34.0

Table 12(3) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

IODINE

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
HI in 3 H_2O	aq			-8.56				
4 H_2O	aq			-10.23				
4.5 H_2O	aq			-10.73				
5 H_2O	aq			-11.09				
6 H_2O	aq			-11.560				
8 H_2O	aq			-12.075				
10 H_2O	aq			-12.335				
12 H_2O	aq			-12.490				
15 H_2O	aq			-12.654				
20 H_2O	aq			-12.794				
25 H_2O	aq			-12.854				
30 H_2O	aq			-12.889				
40 H_2O	aq			-12.930				
50 H_2O	aq			-12.956				
75 H_2O	aq			-12.996				
100 H_2O	aq			-13.014				
200 H_2O	aq			-13.050				
300 H_2O	aq			-13.065				
400 H_2O	aq			-13.074				
500 H_2O	aq			-13.082				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 12(4) IODINE

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
HI in 600 H_2O	aq			-13.088				
800 H_2O	aq			-13.098				
1,000 H_2O	aq			-13.106				
2,000 H_2O	aq			-13.127				
3,000 H_2O	aq			-13.138				
4,000 H_2O	aq			-13.144				
5,000 H_2O	aq			-13.149				
7,000 H_2O	aq			-13.156				
10,000 H_2O	aq			-13.161				
20,000 H_2O	aq			-13.170				
50,000 H_2O	aq			-13.178				
100,000 H_2O	aq			-13.181				
∞ H_2O	aq			-13.19				
HIO undissoc.; std. state, m = 1	aq	143.9118		-33.0	-23.7		22.8	
HIO_3	c	175.9106		-55.0				
undissoc.; std. state, m = 1	aq			-50.5	-31.7		39.9	
in 100 H_2O	aq			-51.7				
200 H_2O	aq			-51.8				
400 H_2O	aq			-52.0				
800 H_2O	aq			-52.2				

Table 12(5) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

IODINE

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
H_2OI^+	std. state, m = 1	aq	144.9197			-25.5			
$H_3IO_6^{2-}$		aq	225.9247		-179.6				
$H_4IO_6^-$		aq	226.9327		-180.4				
H_5IO_6		aq	227.9406		-180.4				
I_2OH^-	std. state, m = 1	aq	270.8162			-55.0			
$I_2O_5 \cdot HIO_3$		c	509.7164		-92.2				
IF		g	145.9028	-22.40	-22.86	-28.32	2.174	56.42	7.99
IF_5		liq	221.8964		-206.7				
		g		-194.29	-196.58	-179.68	4.565	78.3	23.7
IF_5^+		g		117.0	116.20				
IF_7		g	259.8932	-222.4	-225.6	-195.6	5.752	82.8	32.6
ICl		c,α	162.3574		-8.4				
		liq			-5.71	-3.25		32.3	
		g		4.64	4.25	-1.30	2.282	59.140	8.50
	std. state, m = 1	aq				-4.1			
	in CCl_4; std. state, $x_2 = 1$				-3.3	-2.1		36.5	
ICl^+		g		242.4	243.5				
ICl_2^-	std. state, m = 1	aq	197.8104			-38.5			
ICl_3		c	233.2634		-21.4	-5.34		40.0	

Table 12(6) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

IODINE

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
I_2Cl^-	std. state, m = 1	aq	289.2618			-31.7			
IBr		c	206.8134		-2.5				
		g		11.90	9.76	0.89	2.367	61.822	8.71
	std. state, m = 1	aq				-1.0			
	in CCl_4; std. state, x_2 = 1				1.62	-0.4		39.	
IBr^+		g		242.	241.3				
IBr_2^-	std. state, m = 1	aq	286.7224			-29.4			
BrI_2^-	std. state, m = 1	aq	333.7178		-30.6	-26.3		47.2	
$HBrI_2$	std. state, m = 1	aq	334.7258		-30.6	-26.3		47.2	
$IBrCl^-$	std. state, m = 1	aq	242.2664			-35.0			

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 13(1) — ASTATINE

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
At	c		0	0	0			

Table 14(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

SULFUR

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
S	rhombic	c	32.064	0	0	0	1.054	7.60	5.41
	monoclinic	c			0.08				
		g		66.1	66.636	56.949	1.591	40.094	5.658
	in $6CS_2$				0.405				
	$2CS_2$				0.402				
	CCl_4				0.62				
	C_6H_6				0.69				
	$(C_2H_5)_2O$				1.5				
	$CHCl_3$				0.70				
S^+		g		304.95	306.97				
S^{2+}		g		844.8	848.2				
S^{3+}		g		1653.0	1657.9				
S^{4+}		g		2743.6	2750.0				
S^{5+}		g		4415.	4422.				
S^{6+}		g		6445.	6654.				
S^{7+}		g		12925.	12935.				
S^{8+}		g		20508.	20520.				
S^{9+}		g		29247.	29260.				
S^-		g		18.36	17.42				
S^{2-}	std. state, m = 1	aq			7.9	20.5		-3.5	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 14(2) SULFUR

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
S_2	g	64.128	30.647	30.68	18.96	2.141	54.51	7.76
S_2^+	g		254.	255.5				
S_2^{2-} std. state, m = 1	aq			7.2	19.0		6.8	
S_3	g	96.192		31.7				
S_3^+	g			344.				
S_3^{2-} std. state, m = 1	aq			6.2	17.6		15.8	
S_4	g	128.256		32.7				
S_4^+	g			334.				
S_4^{2-} std. state, m = 1	aq			5.5	16.5		24.7	
S_5	g	160.320		29.6				
S_5^+	g			259.				
S_5^{2-} std. state, m = 1	aq			5.1	15.7		33.6	
S_6	g	192.384		24.5				
S_6^+	g			247.				
S_7	g	224.448		27.1				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 14(3) SULFUR

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
S_7^+	g			248.				
S_8	g	256.512	25.35	24.45	11.87	7.531	102.98	37.39
S_8^+	g		247.	247.				
SO	g	48.0634	1.5	1.496	-4.741	2.087	53.02	7.21
SO_2	liq	64.0628		-76.6				
	g		-70.336	-70.944	-71.748	2.521	59.30	9.53
undissoc.; std. state, m = 1	aq			-77.194	-71.871		38.7	
in 100 H_2O	aq			-78.054				
150 H_2O	aq			-78.226				
200 H_2O	aq			-78.355				
250 H_2O	aq			-78.458				
300 H_2O	aq			-78.547				
400 H_2O	aq			-78.691				
500 H_2O	aq			-78.811				
750 H_2O	aq			-79.036				

Table 14(4) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

SULFUR

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
SO_2 in 1,000 H_2O	aq			-79.201				
1,500 H_2O	aq			-79.461				
2,000 H_2O	aq			-79.642				
2,500 H_2O	aq			-79.776				
3,000 H_2O	aq			-79.891				
3,500 H_2O	aq			-79.989				
4,000 H_2O	aq			-80.068				
5,000 H_2O	aq			-80.209				
7,500 H_2O	aq			-80.443				
10,000 H_2O	aq			-80.584				
in dimethylaniline				-81.2				
SO_2^+	g		214.2	215.1				
SO_3 I, β	c	80.0622		-108.63	-88.19		12.5	
	liq			-105.41	-88.04		22.85	
	g		-93.21	-94.58	-88.69	2.796	61.34	12.11

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 14(5) SULFUR

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
SO_3^{2-} std. state, m = 1	aq			-151.9	-116.3		-7.	
SO_4^{2-} std. state, m = 1	aq	96.0616		-217.32	-177.97		4.8	-70.
$S_2O_3^{2-}$	aq	112.1262		-155.9				
$S_2O_4^{2-}$ std. state, m = 1	aq	128.1256		-180.1	-143.5		22.	
$S_2O_6^{2-}$	aq	160.1244		-286.4				
$S_2O_7^{2-}$	aq	176.1238		-334.9				
$S_2O_8^{2-}$ std. state, m = 1	aq	192.1232		-320.0	-265.4		59.3	
$S_3O_6^{2-}$	aq	192.1884		-286.7				
$S_4O_6^{2-}$	aq	224.2524		-292.58				
$S_5O_6^{2-}$	aq	256.3164		-295.5				
HS	g	33.0720	34.	34.10	27.08	2.171	46.74	7.72
HS^- std. state, m = 1	aq			-4.2	2.88		15.0	
H_2S	g	34.0799	-4.232	-4.93	-8.02	2.379	49.16	8.18
std. state, m = 1	aq			-9.5	-6.66		29.	

Table 14(6) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

SULFUR

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
H_2S^+	g		273.0	237.8				
H_2S_2	liq	66.1439		-5.51				20.1
	g			2.53				12.3
$H_2S_2^+$	g			239.				
H_2S_3	liq	98.2079		-7.27				
	g			3.59				
H_2S_4	liq	130.2719		-7.85				
	g			5.71				
H_2S_5	liq	162.3359		-8.35				
	g			7.98				
H_2S_6	liq	194.3999		-8.85				
HSO_3^- std. state, m = 1	aq	81.0702		-149.67	-126.15		33.4	
HSO_4^- std. state, m = 1	aq	97.0696		-212.08	-180.69		31.5	-20.
H_2SO_3 undissoc.; std. state, m = 1	aq	82.0781		-145.51	-128.56		55.5	
in 100 H_2O	aq			-146.369				
150 H_2O	aq			-146.541				
200 H_2O	aq			-146.670				
250 H_2O	aq			-146.773				
300 H_2O	aq			-146.862				
400 H_2O	aq			-147.006				
500 H_2O	aq			-147.126				

Table 14(7) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

SULFUR

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
H_2SO_3 in 750 H_2O	aq			-147.351				
1,000 H_2O	aq			-147.516				
1,500 H_2O	aq			-147.776				
2,000 H_2O	aq			-147.957				
2,500 H_2O	aq			-148.091				
3,000 H_2O	aq			-148.206				
3,500 H_2O	aq			-148.304				
4,000 H_2O	aq			-148.383				
5,000 H_2O	aq			-148.524				
7,500 H_2O	aq			-148.758				
10,000 H_2O	aq			-148.899				
H_2SO_4	c	98.0775	-194.069					
	liq			-194.548	-164.938	6.748	37.501	33.20
std. state, m = 1	aq			-217.32	-177.97		4.8	-70.
in 1.0 H_2O	aq			-201.193				
1.5 H_2O	aq			-203.128				
2.0 H_2O	aq			-204.455				
2.5 H_2O	aq			-205.452				
3.0 H_2O	aq			-206.241				
3.5 H_2O	aq			-206.886				
4.0 H_2O	aq			-207.428				

Table 14(8) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

SULFUR

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
H_2SO_4 in 4.5 H_2O	aq			-207.889				
5.0 H_2O	aq			-208.288				
5.5 H_2O	aq			-208.637				
6 H_2O	aq			-208.944				
7 H_2O	aq			-209.458				
8 H_2O	aq			-209.865				
9 H_2O	aq			-210.190				
10 H_2O	aq			-210.451				
12 H_2O	aq			-210.835				
15 H_2O	aq			-211.191				
20 H_2O	aq			-211.500				
25 H_2O	aq			-211.660				
30 H_2O	aq			-211.755				
40 H_2O	aq			-211.869				
50 H_2O	aq			-211.944				
75 H_2O	aq			-212.068				
100 H_2O	aq			-212.150				
115 H_2O	aq			-212.192				
150 H_2O	aq			-212.282				
200 H_2O	aq			-212.387				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 14(9) SULFUR

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
H_2SO_4 in 300 H_2O	aq			-212.565				
400 H_2O	aq			-212.709				
500 H_2O	aq			-212.833				
600 H_2O	aq			-212.950				
700 H_2O	aq			-213.040				
800 H_2O	aq			-213.128				
900 H_2O	aq			-213.205				
1,000 H_2O	aq			-213.275				
1,500 H_2O	aq			-213.552				
2,000 H_2O	aq			-213.740				
3,000 H_2O	aq			-214.015				
4,000 H_2O	aq			-214.220				
5,000 H_2O	aq			-214.390				
7,000 H_2O	aq			-214.675				
10,000 H_2O	aq			-215.060				
15,000 H_2O	aq			-215.553				
20,000 H_2O	aq			-215.880				
30,000 H_2O	aq			-216.232				
50,000 H_2O	aq			-216.545				
70,000 H_2O	aq			-216.706				

Table 14(10) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

SULFUR

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
H_2SO_4 in 100,000 H_2O	aq			-216.855				
150,000 H_2O	aq			-216.971				
200,000 H_2O	aq			-217.042				
300,000 H_2O	aq			-217.120				
500,000 H_2O	aq			-217.187				
700,000 H_2O	aq			-217.221				
1,000,000 H_2O	aq			-217.246				
2,000,000 H_2O	aq			-217.277				
∞ H_2O	aq			-217.32				
in 10 C_2H_5OH				-209.55				
15 C_2H_5OH				-210.30				
20 C_2H_5OH				-210.95				
25 C_2H_5OH				-211.35				
49 C_2H_5OH				-212.05				
in 5 $(C_2H_5)_2O$				-205.93				
10 $(C_2H_5)_2O$				-207.15				
15 $(C_2H_5)_2O$				-208.15				
20 $(C_2H_5)_2O$				-208.91				
25 $(C_2H_5)_2O$				-209.51				
in CH_2ClCH_2Cl				-190.2				

Table 14(11) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

SULFUR

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
in 5 $(CH_3)_2SO_4$				-197.00				
10 $(CH_3)_2SO_4$				-197.45				
15 $(CH_3)_2SO_4$				-197.60				
20 $(CH_3)_2SO_4$				-197.80				
25 $(CH_3)_2SO_4$				-197.90				
in 5 $C_6H_5NO_2$				-195.75				
10 $C_6H_5NO_2$				-196.05				
15 $C_6H_5NO_2$				-196.25				
20 $C_6H_5NO_2$				-196.43				
25 $C_6H_5NO_2$				-196.55				
49 $C_6H_5NO_2$				-196.84				
$H_2SO_4 \cdot 1H_2O$	liq	116.0929		-269.508	-227.182		50.56	51.35
$H_2SO_4 \cdot 2H_2O$	liq	134.1082		-341.085	-286.770		66.06	62.34
$H_2SO_4 \cdot 3H_2O$	liq	152.1236		-411.186	-345.178		82.55	76.23
$H_2SO_4 \cdot 4H_2O$	liq	170.1389		-480.688	-403.001		99.09	91.35
$H_2SO_4 \cdot 6.5\ H_2O$	liq	215.1772		-653.264	-546.403		140.51	136.30
$HS_2O_4^-$ std. state, m = 1	aq	129.1336			-146.9			
$H_2S_2O_4$ std. state, m = 1	aq	130.1415			-147.4			

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 14(12) SULFUR

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$H_2S_2O_6$	aq	162.1403		-286.4				
$H_2S_2O_7$	c	178.1397		-304.4				27.
$H_2S_2O_8$ std. state, m = 1	aq	194.1391		-320.0	-265.4		59.3	
SF_4	g	108.0576	-183.4	-185.2	-174.8	3.482	69.77	17.45
SF_6	g	146.0544	-285.7	-289.	-264.2	4.056	69.72	23.25
std. state, m = 1	aq			-293.0	-259.3		39.8	
SO_3F^-	aq	99.0606		-193.0				
SOF_2	g	86.0602				2.997	66.58	13.58
SO_2F_2	g	102.0596				3.241	67.86	15.78
$HF \cdot SO_2$	g	84.0692		-139.2				
HSO_3F	liq	100.0686		-186.				
	aq			-191.9				
SCl_2	liq	102.970		-12.				
	g			-4.7				
S_2Cl_2	liq	135.034		-14.2				
	g		-4.18	-4.4	-7.6	4.082	79.2	17.6
S_3Cl_2	liq	167.098		-12.4				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 14(13) SULFUR

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
S_4Cl_2	liq	199.162		-10.2				
S_5Cl_2	liq	231.226		-8.8				
$SOCl_2$	liq	118.9694		-58.7				29.
	g		-50.07	-50.8	-47.4	3.559	74.01	15.9
in C_6H_6				-59.7				
SO_2Cl_2	liq	134.9688		-94.2				32.
	g		-85.50	-87.0	-76.5	3.825	74.53	18.4
in C_6H_6				-94.2				
$S_2O_5Cl_2$	liq	215.0310		-168.7				56.
	g			-153.2				
$SO_2 \cdot HCl$	g	100.5238		-96.5				
HSO_3Cl	liq	116.5232		-143.7				
SF_5Cl	liq	162.5090		-254.7				
	g		-247.48	-250.5	-226.9	4.396	76.26	24.9
S_2Br_2	liq	223.946		-3.				
$SOBr_2$	g	207.8814	-17.7	-21.8				

Table 15(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

SELENIUM

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
Se	hexagonal, black	c	78.96	0	0	0	1.319	10.144	6.062
	monoclinic, red	c			1.6				
		g		54.11	54.27	44.71	1.4827	42.22	5.020
	glassy	amorp			1.2				
Se^{2-}	std. state, m = 1	aq				30.9			
Se_2		g	157.92	35.26	34.9	23.0	2.275	60.2	8.46
Se_6		g	473.76		39.2				
SeO		g	94.959	13.0	12.75	6.41	2.108	55.9	7.47
SeO_2		c	110.959		-53.86				
		aq			-52.97				
SeO_3		c	126.958		-39.9				
SeO_3^{2-}	std. state, m = 1	aq			-121.7	-88.4		3.	
SeO_4^{2-}	std. state, m = 1	aq	142.958		-143.2	-105.5		12.9	
Se_2O_5		c	237.917		-97.6				
HSe^-	std. state, m = 1	aq	79.968		3.8	10.5		19.	
H_2Se		g	80.976	8.05	7.1	3.8	2.391	52.32	8.30
	std. state, m = 1	aq			4.6	5.3		39.1	
$HSeO_3^-$	std. state, m = 1	aq	127.966		-122.98	-98.36		32.3	
$HSeO_4^-$	std. state, m = 1	aq	143.966		-139.0	-108.1		35.7	

Table 15(2) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

SELENIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
H_2SeO_3	c	128.974		-125.35				
undissoc.; std. state, m = 1	aq			-121.29	-101.87		49.7	
	aq			-121.24				
H_2SeO_4	c	144.974		-126.7				
in 7.85 H_2O				-134.4				
500 H_2O				-140.1				
1,200 H_2O				-140.3				
$H_2SeO_4 \cdot H_2O$	c	162.989		-200.9				
	liq			-196.1				
SeF_6	g	192.950	-264.1	-267.	-243.	4.740	74.99	26.4
$SeCl_2$	g	149.866		-7.6				
$SeCl_4$	c	220.772		-43.8				
Se_2Cl_2	liq	228.826		-19.7				
	g			4.				
$SeOCl_2$	g	165.865		-6.				
$Se(OH)_3 \cdot ClO_4$	c	229.433		-147.4				
$SeBr_2$	g	238.778		-5.				
Se_2Br_2	g	317.738		7.				
$SeO_2 \cdot SO_3$	c	191.021		-164.7				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 16(1) TELLURIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Te	c	127.60	0	0	0	1.463	11.88	6.15
	g		47.	47.02	37.55	1.481	43.65	4.968
	amorp			2.7				
Te^{+}	g		254.76	256.26				
Te^{2+}	g		684.	687.				
Te^{3+}	g		1390.	1394.				
Te^{4+}	g		2262.	2268.				
Te^{5+}	g		3652.	3659.				
Te^{6+}	g		5320.	5329.				
Te^{7+}	g		8485.	8495.				
Te_2	g	255.20	40.75	40.2	28.2	2.379	64.06	8.78
TeO	g	143.599	16.	15.6	9.2	2.093	57.7	7.19
TeO_2	c	159.599		-77.1	-64.6		19.0	
TeO_3^{2-}	aq	175.598		-142.6				
H_2Te	g	129.616		23.8				
H_2TeO_3 std. state, m = 1	aq	177.614			-76.2			
$Te(OH)_3^{+}$ std. state, m = 1	aq	178.622		-145.4	-118.6		26.7	
$H_4TeO_6^{2-}$	aq	227.628		-292.1				
$H_5TeO_6^{-}$	aq	228.636		-301.5				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 16(2) TELLURIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
H_6TeO_6	c	229.644		-310.4				
	aq			-307.				
TeF_6	g	241.590		-315.				
$TeCl_4$	c	269.412		-78.0				33.1
$TeBr_4$	c	447.236		-45.5				
$2TeO_2 \cdot SO_3$	c	399.260		-314.9				
TeSe	g	206.56	38.4	38.0	26.0		63.5	

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 17(1) POLONIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Po	c	210.	0	0	0			
Po^{2+} std. state, m = 1	aq				17.			
Po^{4+} std. state, m = 1	aq				70.			
$Po(OH)_2^{4+}$ std. state, m = 1	aq	244.0			-113.			
$Po(OH)_4$	c	278.0			-130.			
$PoCl_6^{2-}$ std. state, m = 1	aq	422.7			-138.			
PoS	c	242.1			52.			

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 18(1) NITROGEN

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
N	g	14.0067	112.534	112.979	108.883	1.481	36.622	4.968
N^+	g		447.663	449.589				
N^{2+}	g		1130.55	1133.96				
N^{3+}	g		2224.52	2229.41				
N^{4+}	g		4011.04	4017.41				
N^{5+}	g		6268.41	6276.26				
N^{6+}	g		18999.5	19008.9				
N^{7+}	g		34381.1	34392.0				
N_2	g	28.0134	0	0	0	2.072	45.77	6.961
N_3^+	g	42.0201	389.	390.2				
N_3^-	g		45.	43.2				
std. state, m = 1	aq			65.76	83.2		25.8	
NO	g	30.0061	21.45	21.57	20.69		50.347	7.133
NO^+	g		234.8	236.4				
NO_2	g	46.0055	8.60	7.93	12.26	2.438	57.35	8.89
NO_2^+	g		276.6	277.4				
NO_2^- std. state, m = 1	aq			-25.0	-8.9		33.5	-23.3
NO_3^- nitrate; std. state, m = 1	aq	62.0049		-49.56	-26.61		35.0	-20.7
peroxynitrite	aq			-10.7				

Table 18(2) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity
NITROGEN

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
N_2O	g	44.0128	20.435	19.61	24.90	2.284	52.52	9.19
	aq			13.4				
$N_2O_2^{2-}$ hyponitrite	aq	60.0122		-4.1				
N_2O_3	liq	76.0116		12.02				
	g		21.628	20.01	33.32	3.566	74.61.	15.68
N_2O_4	liq	92.0110		-4.66	23.29		50.0	34.1
	g		4.49	2.19	23.38	3.918	72.70	18.47
N_2O_5	c	108.0104		-10.3	27.2		42.6	34.2
	g		5.7	2.7	27.5	4.237	85.0	20.2
NH	g	15.0147	79.	79.				
NH_2	g	16.0226		41.				
NH_3	g	17.0306	-9.34	-11.02	-3.94	2.388	45.97	8.38
undissoc.; std. state, m = 1	aq			-19.19	-6.35		26.6	
in 1 H_2O	aq			-18.011				
2 H_2O	aq			-18.560				
5 H_2O	aq			-18.945				
10 H_2O	aq			-19.074				
20 H_2O	aq			-19.125				
50 H_2O	aq			-19.156				
100 H_2O	aq			-19.167				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 18(3) NITROGEN

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
NH_3 in 500 H_2O	aq			-19.173				
1,000 H_2O	aq			-19.171				
5,000 H_2O	aq			-19.154				
10,000 H_2O	aq			-19.140				
50,000 H_2O	aq			-19.086				
100,000 H_2O	aq			-19.047				
in $(C_2H_5)_2O$				-4.0				
NH_3^+	g		224.7	224.53				
NH_4^+ std. state, m = 1	aq	18.0386		-31.67	-18.97		27.1	19.1
N_2H_4	liq	32.0453		12.10	35.67		28.97	23.63
	g		26.18	22.80	38.07	2.743	56.97	11.85
undissoc.; std. state, m = 1	aq			8.20	30.6		33.	
$N_2H_5^+$ std. state, m = 1	aq	33.0532		-1.8	19.7		36.	16.8
HN_3	liq	43.0281		63.1	78.2		33.6	
	g		71.82	70.3	78.4	2.599	57.09	10.44
undissoc.; std. state, m = 1	aq			62.16	76.9		34.9	
HN_3^+	g		309.	309.				

Table 18(4) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

NITROGEN

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
NH_4N_3	c	60.0587		27.6	65.5		26.9	
std. state, m = 1	aq			34.1	64.3		52.7	
HNO_2 cis	g	47.0135	-17.12	-18.64	-10.27	2.608	59.43	10.70
trans	g		-17.68	-19.15	-10.82	2.652	59.54	11.01
cis-trans mixture, equil.	g			-19.0	-11.0		60.7	10.9
undissoc.; std. state, m = 1	aq			-28.5	-13.3		36.5	
HNO_3	liq	63.0129		-41.61	-19.31		37.19	26.26
	g		-29.94	-32.28	-17.87	2.815	63.64	12.75
std. state, m = 1	aq			-49.56	-26.61		35.0	-20.7
in 1 H_2O	aq			-44.845				
2 H_2O	aq			-46.500				
3 H_2O	aq			-47.459				
4 H_2O	aq			-48.065				
5 H_2O	aq			-48.462				
7 H_2O	aq			-48.899				
10 H_2O	aq			-49.192				
15 H_2O	aq			-49.357				
25 H_2O	aq			-49.430				
50 H_2O	aq			-49.439				
100 H_2O	aq			-49.440				

Table 18(5) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

NITROGEN

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
HNO_3 in 500 H_2O	aq			-49.468				
1,000 H_2O	aq			-49.484				
2,000 H_2O	aq			-49.501				
5,000 H_2O	aq			-49.518				
10,000 H_2O	aq			-49.529				
50,000 H_2O	aq			-49.545				
∞ H_2O	aq			-49.56				
$HNO_3 \cdot H_2O$	liq	81.0282		-113.16	-78.61		51.84	43.61
$HNO_3 \cdot 3H_2O$	liq	117.0589		-252.40	-193.91		82.93	77.71
NH_2OH	c	33.0300		-27.3				
	aq			-23.5				
$NH_2OH_2^+$	aq	34.0380		-32.8				
NH_4OH	liq	35.0460		-86.33	-60.74		39.57	37.02
undissoc.; std. state, m = 1	aq			-87.505	-63.04		43.3	
ionized; std. state, m = 1	aq			-86.64	-56.56		24.5	-16.4
in 1 H_2O	aq			-86.875				
1.5 H_2O	aq			-86.998				
2 H_2O	aq			-87.078				
2.5 H_2O	aq			-87.138				
3 H_2O	aq			-87.188				

Table 18(6) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

NITROGEN

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
NH_4OH in 3.5 H_2O	aq			-87.228				
4 H_2O	aq			-87.260				
4.5 H_2O	aq			-87.286				
5 H_2O	aq			-87.307				
6 H_2O	aq			-87.338				
8 H_2O	aq			-87.377				
10 H_2O	aq			-87.396				
12 H_2O	aq			-87.412				
15 H_2O	aq			-87.427				
20 H_2O	aq			-87.443				
25 H_2O	aq			-87.454				
30 H_2O	aq			-87.458				
40 H_2O	aq			-87.470				
50 H_2O	aq			-87.474				
75 H_2O	aq			-87.480				
100 H_2O	aq			-87.483				
200 H_2O	aq			-87.486				
400 H_2O	aq			-87.489				
500 H_2O	aq			-87.488				
1,000 H_2O	aq			-87.486				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 18(7) NITROGEN

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
NH_4OH in 2,000 H_2O	aq			-87.481				
3,000 H_2O	aq			-87.478				
4,000 H_2O	aq			-87.473				
5,000 H_2O	aq			-87.469				
7,000 H_2O	aq			-87.464				
10,000 H_2O	aq			-87.455				
20,000 H_2O	aq			-87.440				
50,000 H_2O	aq			-87.401				
100,000 H_2O	aq			-87.362				
∞ H_2O	aq			-86.64				
NH_4HO_2 std. state, m = 1	aq	51.0454		-69.99	-35.1		32.8	
$HN_2O_2^-$ hyponitrite ion	aq	61.0202		-12.4				
$H_2N_2O_2$ hyponitrous acid	aq	62.0281		-15.4				
NH_2NO_2 nitramide	c	62.0281		-21.4				
NH_4NO_2	c	64.0441		-61.3				
std. state, m = 1	aq			-56.7	-27.9		60.6	-4.2
NH_4NO_3	c	80.0435		-87.37	-43.98		36.11	33.3
std. state, m = 1	aq			-81.23	-45.58		62.1	-1.6

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 18(8) NITROGEN

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
NH_4NO_3 in 3.0 H_2O	aq			-83.485				
3.5 H_2O	aq			-83.320				
4.0 H_2O	aq			-83.218				
4.5 H_2O	aq			-83.130				
5 H_2O	aq			-83.050				
6 H_2O	aq			-82.905				
7 H_2O	aq			-82.775				
8 H_2O	aq			-82.660				
10 H_2O	aq			-82.470				
12 H_2O	aq			-82.336				
15 H_2O	aq			-82.080				
20 H_2O	aq			-82.000				
25 H_2O	aq			-81.866				
30 H_2O	aq			-81.765				
40 H_2O	aq			-81.626				
50 H_2O	aq			-81.538				
75 H_2O	aq			-81.412				
100 H_2O	aq			-81.340				
150 H_2O	aq			-81.266				
200 H_2O	aq			-81.232				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 18(9) NITROGEN

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
NH_4NO_3 in 300 H_2O	aq			-81.203				
400 H_2O	aq			-81.189				
500 H_2O	aq			-81.183				
600 H_2O	aq			-81.179				
800 H_2O	aq			-81.177				
1,000 H_2O	aq			-81.177				
2,000 H_2O	aq			-81.182				
3,000 H_2O	aq			-81.187				
4,000 H_2O	aq			-81.191				
5,000 H_2O	aq			-81.194				
7,000 H_2O	aq			-81.198				
10,000 H_2O	aq			-81.202				
20,000 H_2O	aq			-81.208				
50,000 H_2O	aq			-81.216				
100,000 H_2O	aq			-81.220				
∞ H_2O	aq			-81.23				

Table 18(10) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

NITROGEN

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
NH_4ONO_2 ammonium peroxynitrite	aq	80.0435		-42.4				
$NH_2OH \cdot HNO_3$	c	96.0429		-87.6				
	aq			-82.4				
N_2H_5OH	liq	50.0606		-58.01				
	g			-49.0	-18.9		63.	
undissoc.; std. state, m = 1	aq			-60.11	-26.1		49.7	17.5
in 75 H_2O	aq			-60.089				
100 H_2O	aq			-60.095				
150 H_2O	aq			-60.101				
200 H_2O	aq			-60.105				
500 H_2O	aq			-60.107				
$(NH_4)_2O$	liq	52.0766		-102.94	-63.84		63.94	59.08
$NH_4HN_2O_2$	aq	79.0588		-44.1				
$N_2H_5NO_3$	c	95.0582		-60.13				
std. state, m = 1	aq			-51.41	-6.91		71.	
$(NH_4)_2N_2O_2$	aq	96.0894		-67.4				
NF_2	g	52.0035	10.92	10.3	13.8	2.527	59.71	9.80
NF_2^+	g		283.	284.				
NF_3	g	71.0019	-28.43	-29.8	-19.9	2.827	62.29	12.7

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 18(11) NITROGEN

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
N_2F_2 cis, active	g	66.0102		16.6				
trans	g			19.6				
N_2F_4	g	104.0070	0.88	-1.7	19.4	3.710	71.96	18.9
NOF	g	49.0045	-15.33	-15.9	-12.2	2.557	59.27	9.88
NO_2F	g	65.0039				2.755	62.2	11.9
NH_4F	c	37.0370	-107.41	-110.89	-83.36	2.655	17.20	15.60
std. state, m = 1	aq			-111.17	-85.61		23.8	-6.4
$NH_4F \cdot H_2O$	c	55.0523				6.146	34.92	37.22
NF_2H	g	53.0115				2.582	60.40	10.37
NH_4HF_2	c	57.0434	-187.94	-191.9	-155.6	4.243	27.61	25.50
std. state, m = 1	aq			-187.01	-157.15		49.2	
in 4.54 H_2O; saturated	aq			-186.8				
600 H_2O	aq			-187.1				
$NH_4H_3F_4$	liq	97.0561		-336.8				
NCl_3	liq	120.3657		55.				
in CCl_4				55.0				
NOCl	g	65.4591	12.81	12.36	15.79	2.716	62.52	10.68
std. state, m = 1	aq				16.04			

Table 18(12) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

NITROGEN

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
NO_2Cl	g	81.4585	4.29	3.0	13.0	2.915	65.02	12.71
$NOClO_4$	c	129.4567		-36.9				
NO_2ClO_4	c	145.4561		8.7				
NH_4Cl	c	53.4916		-75.15	-48.51		22.6	20.1
std. state, m = 1	aq			-71.62	-50.34		40.6	-13.5
in 8 H_2O	aq			-71.590				
10 H_2O	aq			-71.567				
12 H_2O	aq			-71.551				
15 H_2O	aq			-71.531				
20 H_2O	aq			-71.512				
25 H_2O	aq			-71.500				
30 H_2O	aq			-71.492				
40 H_2O	aq			-71.486				
50 H_2O	aq			-71.484				
100 H_2O	aq			-71.487				
150 H_2O	aq			-71.496				
200 H_2O	aq			-71.503				
300 H_2O	aq			-71.515				
400 H_2O	aq			-71.522				
500 H_2O	aq			-71.528				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 18(13) NITROGEN

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
NH_4Cl in 600 H_2O	aq			-71.533				
700 H_2O	aq			-71.538				
800 H_2O	aq			-71.541				
900 H_2O	aq			-71.544				
1,000 H_2O	aq			-71.547				
1,500 H_2O	aq			-71.557				
2,000 H_2O	aq			-71.563				
3,000 H_2O	aq			-71.572				
4,000 H_2O	aq			-71.576				
5,000 H_2O	aq			-71.580				
7,000 H_2O	aq			-71.586				
10,000 H_2O	aq			-71.591				
20,000 H_2O	aq			-71.598				
50,000 H_2O	aq			-71.606				
100,000 H_2O	aq			-71.610				
∞ H_2O	aq			-71.62				
NH_4Cl_3 std. state, m = 1	aq	124.3976			-39.			
N_2H_5Cl	c	68.5062		-47.0				

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Table 18(14) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — NITROGEN

Substance: Formula and Description		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
N_2H_5Cl	std. state, m = 1	aq			-41.8	-11.7		49.5	-15.8
	in 50 H_2O	aq			-41.868				
	75 H_2O	aq			-41.835				
	100 H_2O	aq			-41.822				
	200 H_2O	aq			-41.807				
	500 H_2O	aq			-41.802				
	∞ H_2O	aq			-41.8				
$N_2H_5Cl \cdot HCl$		c	104.9672		-87.8				
$NH_2OH \cdot HCl$		c	69.4910		-75.9				22.2
		aq			-72.6				
NH_4ClO	std. state, m = 1	aq	69.4910		-57.3	-27.8		37.	
NH_4ClO_2	std. state, m = 1	aq	85.4904		-47.6	-14.9		51.3	
NH_4ClO_3	std. state, m = 1	aq	101.4898		-55.4	-19.8		65.9	
NH_4ClO_4		c	117.4892		-70.58	-21.25		44.5	
	std. state, m = 1	aq			-62.58	-21.03		70.6	
$N_2H_5ClO_4$		c	132.5038		-42.2				
	std. state, m = 1	aq			-32.7	17.6		79.7	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 18(15) NITROGEN

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$N_2H_5ClO_4$ in 50 H_2O	aq			-33.775				
100 H_2O	aq			-33.330				
200 H_2O	aq			-33.052				
300 H_2O	aq			-32.960				
500 H_2O	aq			-32.880				
1,000 H_2O	aq			-32.815				
∞ H_2O	aq			-32.7				
$N_2H_5ClO_4 \cdot 1/2\ H_2O$	c	141.5115		-78.18				
NOBr	g	109.9151	21.86	19.64	19.70	2.785	65.38	10.87
NH_4Br	c	94.9477		-64.73	-41.9		27.	23.
std. state, m = 1	aq			-60.72	-43.82		46.8	-14.8
in 100 H_2O	aq			-60.614				
150 H_2O	aq			-60.615				
200 H_2O	aq			-60.620				
300 H_2O	aq			-60.625				
400 H_2O	aq			-60.630				
500 H_2O	aq			-60.634				
600 H_2O	aq			-60.640				
700 H_2O	aq			-60.644				
800 H_2O	aq			-60.646				
1000 H_2O	aq			-60.650				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 18(16) NITROGEN

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
NH_4Br in 1,500 H_2O	aq			-60.659				
2,000 H_2O	aq			-60.665				
3,000 H_2O	aq			-60.674				
4,000 H_2O	aq			-60.677				
5,000 H_2O	aq			-60.681				
7,000 H_2O	aq			-60.687				
10,000 H_2O	aq			-60.691				
20,000 H_2O	aq			-60.698				
50,000 H_2O	aq			-60.706				
100,000 H_2O	aq			-60.710				
∞ H_2O	aq			-60.72				
NH_4Br_3	c	257.7657		-67.5	-45.1		65.	
std. state, m = 1	aq			-62.84	-44.56		78.6	
NH_4Br_5 std. state, m = 1	aq	417.5837		-65.7	-43.8		102.8	
N_2H_5Br	c	112.9622		-37.2				
std. state, m = 1	aq			-30.8	-5.2		55.7	-17.1
in 50 H_2O	aq			-31.010				
100 H_2O	aq			-30.885				
200 H_2O	aq			-30.825				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 18(17) NITROGEN

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
N_2H_5Br in 500 H_2O	aq			-30.809				
1,000 H_2O	aq			-30.805				
∞ H_2O	aq			-30.8				
$N_2H_5Br \cdot HBr$	c	193.8792		-64.8				
$N_2H_5Br \cdot HBr \cdot 2H_2O$	c	229.9099		-206.6				
$NH_4Br \cdot 1.5NH_3$	c	123.4935		-93.9	-47.0		51.	
NH_4BrO std. state, m = 1	aq	113.9470		-54.2	-27.0		37.	
NH_4BrO_3 std. state, m = 1	aq	145.9458		-51.7	-18.6		66.1	
NH_4Br_2Cl std. state, m = 1	aq	213.3096		-72.4	-49.7		72.2	
NH_4I	c	144.9430		-48.14	-26.9		28.	
std. state, m = 1	aq			-44.86	-31.30		53.7	-14.9
in 100 H_2O	aq			-44.784				
150 H_2O	aq			-44.782				
200 H_2O	aq			-44.780				
300 H_2O	aq			-44.775				
400 H_2O	aq			-44.778				
500 H_2O	aq			-44.780				
600 H_2O	aq			-44.786				
800 H_2O	aq			-44.788				
1,000 H_2O	aq			-44.792				

Table 18(18) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

NITROGEN

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
NH_4I in 1,500 H_2O	aq			-44.801				
2,000 H_2O	aq			-44.807				
4,000 H_2O	aq			-44.818				
5,000 H_2O	aq			-44.822				
7,000 H_2O	aq			-44.828				
10,000 H_2O	aq			-44.832				
20,000 H_2O	aq			-44.839				
50,000 H_2O	aq			-44.847				
100,000 H_2O	aq			-44.850				
∞ H_2O	aq			-44.86				
NH_4I_3	c	398.7518		-49.7	-28.6		56.1	
std. state, m = 1	aq			-44.0	-31.3		84.3	
$NH_4I \cdot NH_3$	c	161.9736		-69.0	-31.5		43.1	
NH_3NI_3	c	411.7505		36.9				
$NH_4I \cdot 2NH_3$	c	179.0042		-89.6	-35.0		55.5	
NH_4IO std. state, m = 1	aq	160.9424		-57.4	-28.2		25.8	
NH_4IO_3	c	192.9412		-92.2				
std. state, m = 1	aq			-84.6	-49.6		55.4	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 18(19) NITROGEN

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
NH_4IO_4		aq	208.9406		-66.9				
$NH_4H_4IO_6$		aq	244.9713		-212.1				
NH_4I_2OH	std. state, m = 1	aq	288.8548			-74.0			
$(NH_4)_2H_3IO_6$		aq	262.0019		-242.9				
$(NH_4)_2I_2O$	std. state, m = 1	aq	305.8854			-57.6			
NH_4ICl_2		c	215.8490			-55.5			
	std. state, m = 1	aq				-57.5			
NH_4ICl_4		c	286.7550			-59.2			
NH_4I_2Cl	std. state, m = 1	aq	307.3004			-50.7			
NH_4IBr_2		c	304.7610		-70.8	-46.9		55.4	
	std. state, m = 1	aq				-48.4			
NH_4BrI_2	std. state, m = 1	aq	351.7564		-62.3	-45.3		74.3	
NH_4IBrCl		c	260.3050			-52.0			
	std. state, m = 1	aq				-54.0			
N_4S_4		c	184.2828		128.0				
$N_2O_3(SO_3)_2$		c	236.1360		-253.				
NH_4HS		c	51.1106		-37.5	-12.1		23.3	
	std. state, m = 1	aq			-35.9	-16.09		42.1	

Table 18(20) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

NITROGEN

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
NH_4HS	in 200 H_2O	aq			-34.8				
S_7NH		c	239.4627		-67.4				
$(NH_4)_2S$	std. state, m = 1	aq	68.1412		-55.4	-17.4		50.7	
$(NH_4)_2S_2$	std. state, m = 1	aq	100.2052		-56.1	-18.9		61.0	
$(NH_4)_2S_3$	std. state, m = 1	aq	132.2692		-57.1	-20.3		70.0	
$(NH_4)_2S_4$		c	164.3332		-65.2				
	std. state, m = 1	aq			-57.8	-21.4		78.9	
$(NH_4)_2S_5$		c	196.3972		-65.6				
	std. state, m = 1	aq			-58.2	-22.2		87.8	
$(NH_4)_2S_8$		c	292.5892		-66.0				
H_2NSO_3H	sulfamic acid	c	97.0928		-161.3				
		aq			-156.3				
NH_4HSO_3		c	99.1088		-183.7				
	std. state, m = 1	aq			-181.34	-145.12		60.5	
	in 300 H_2O	aq			-181.3				
NH_4HSO_4		c	115.1082		-245.45				
	std. state, m = 1	aq			-243.75	-199.66		58.6	-0.9
	in 200 H_2O	aq			-245.65				
$NH_2OH \cdot H_2SO_4$		aq	131.1076		-246.7				
$NH_4HS_2O_4$	std. state, m = 1	aq	147.1722			-165.9			

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 18(21) NITROGEN

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$SO_2(NH_2)_2$ sulfamide	c	96.1081		-129.3				
$(NH_4)_2SO_3$	c	116.1394		-211.6				
std. state, m = 1	aq			-215.2	-154.2		47.2	
in 400 H_2O	aq			-211.0				
$(NH_4)_2SO_3 \cdot H_2O$	c	134.1547		-283.8				
$(NH_4)_2SO_4$	c	132.1388		-282.23	-215.56		52.6	44.81
std. state, m = 1	aq			-280.66	-215.77		58.6	-31.8
in 10 H_2O	aq			-280.72				
30 H_2O	aq			-280.58				
50 H_2O	aq			-280.51				
100 H_2O	aq			-280.407				
200 H_2O	aq			-280.321				
400 H_2O	aq			-280.25				
500 H_2O	aq			-280.242				
1,000 H_2O	aq			-280.217				
2,000 H_2O	aq			-280.217				
∞ H_2O	aq			-280.66				
$(NH_2OH)_2 \cdot H_2SO_4$	aq	164.1376		-281.3				
$(NH_4)_2S_2O_3$	aq	148.2034		-219.2				
$(NH_4)_2S_2O_4$ std. state, m = 1	aq	164.2028		-243.4	-181.4		76.	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 18(22) NITROGEN

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^{\circ\prime}$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$(NH_4)_2S_2O_6$	aq	196.2016		-349.7				
$(NH_4)_2S_2O_7$	aq	212.2010		-398.2				
$(NH_4)_2S_2O_8$	c	228.2004		-392.5				
std. state, m = 1	aq			-383.3	-303.3		113.5	
$(NH_4)_2S_3O_6$	aq	228.2656		-350.0				
$(NH_4)_2S_4O_6$	aq	260.3296		-355.92				
$(NH_4)_2S_5O_6$	aq	292.3936		-358.8				
$(N_2H_5)_2SO_4$	c	162.1681		-229.2				
std. state, m = 1	aq			-221.0	-138.6		77.	-36.
$(N_2H_5)_2SO_4 \cdot H_2O$	c	180.1834		-291.3				
$(NH_4)_2SO_4 \cdot 3NH_3$	c	183.2306		-341.7	-223.7		89.5	
NSF	g	65.0691				2.678	62.07	10.55
NSF_3	g	103.0659				3.471	68.48	17.18
NH_4SO_3F	aq	117.0992		-224.7				
$NH_4I \cdot 3SO_2$	c	337.1314		-289.2	-238.9		100.3	
NSe	c	92.967		42.3				
NH_4HSe	c	98.006		-31.8	-5.6		23.1	
std. state, m = 1	aq			-27.9	-8.5		46.	
	aq			-28.2				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 18(23) NITROGEN

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$(NH_4)_2Se$ std. state, m = 1	aq	115.037			-7.0			
NH_4HSeO_3 std. state, m = 1	aq	146.005		-154.65	-117.33		60.2	
NH_4HSeO_4 std. state, m = 1	aq	162.004		-170.7	-127.1		62.8	
$(NH_4)_2SeO_3$ std. state, m = 1	aq	163.035		-185.0	-126.3		57.3	
$(NH_4)_2SeO_4$	c	179.035		-209.0				
std. state, m = 1	aq			-206.5	-143.4		67.1	
NH_4HTe	c	146.646		0.3				
$NH_4H_5TeO_6$	aq	246.675		-333.2				
$(NH_4)_2TeO_3$	aq	211.675		-205.9				
$(NH_4)_2H_4TeO_6$	aq	263.705		-355.4				
$(NH_4)_2PoCl_6$ std. state, m = 1	aq	458.8			-176.			

Table 19(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

PHOSPHORUS

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
P α, white	c	30.9738	0	0	0	1.281[a]	9.82	5.698
red, triclinic	c		-3.78	-4.2	-2.9	0.862	5.45	5.07
black	c			-9.4				
red	amorp			-1.8				
	g		75.	75.20	66.51	1.481	38.978	4.968
in CS_2				0.5				
P^+	g		328.20	329.88				
P^{2+}	g		781.51	784.67				
P^{3+}	g		1477.11	1481.75				
P^{4+}	g		2661.67	2667.79				
P^{5+}	g		4161.2	4168.8				
P^{6+}	g		9245.	9254.				
P^{7+}	g		15319.	15330.				
P^{8+}	g		22453.	22465.				
P^{9+}	g		31048.	31062.				
P^{10+}	g		40862.	40877.				
P^{11+}	g		51920.	51937.				
P^{12+}	g		64845.	64863.				
P^{13+}	g		78949.	78969.				
P_2	g	61.9476	34.94	34.5	24.8	2.126	52.108	7.66

[a]Relative to P, α, white

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 19(2) PHOSPHORUS

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
P_4	g	123.8952	15.83	14.08	5.85	3.378	66.89	16.05
PO	g	46.9732					53.221	
PO_3^-	aq	78.9720		-233.5				
PO_4^{3-} std. state, m = 1	aq	94.9714		-305.3	-243.5		-53.	
$P_2O_7^{4-}$ std. state, m = 1	aq	173.9434		-542.8	-458.7		-28.	
P_4O_6	c	219.8916		-392.0				
P_4O_{10} hexagonal	c	283.8892	-705.82	-713.2	-644.8	8.117	54.70	50.60
	amorp			-727.				
PH_3	g	33.9977	3.20	1.3	3.2	2.420	50.22	8.87
std. state, m = 1	aq			-2.16	0.35		48.2	
PH_3^+	g		243.	242.6				
PH_4^+ std. state, m = 1	aq	35.0057			16.2			
P_2H_4	liq	65.9795		-1.2				
	g			5.0				
HPO_3	c	79.9800		-226.7				
	aq			-233.5				

Table 19(3) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

PHOSPHORUS

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
HPO_3^{2-}	aq			-231.6				
HPO_4^{2-} std. state, m = 1	aq	95.9794		-308.83	-260.34		-8.0	
$H_2PO_2^-$	aq	64.9885		-146.7				
$H_2PO_3^-$	aq	80.9879		-231.7				
$H_2PO_4^-$ std. state, m = 1	aq	96.9873		-309.82	-260.17		21.6	
H_3PO_2	c	65.9965		-144.5				
	liq			-142.3				
in 50 H_2O	aq			-143.6				
100 H_2O	aq			-144.0				
200 H_2O	aq			-144.4				
400 H_2O	aq			-144.7				
H_3PO_3	c	81.9959		-230.5				
	aq			-230.6				
H_3PO_4	c	97.9953	-301.29	-305.7	-267.5	4.059	26.41	25.35
	liq			-302.8				
ionized, std. state, m = 1	aq			-305.3	-243.5		-53.	
undissoc.; std. state, m = 1	aq			-307.92	-273.10		37.8	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 19(4) PHOSPHORUS

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
H_3PO_4 in 0.75 H_2O	aq			-303.96				
1.0 H_2O	aq			-304.69				
1.5 H_2O	aq			-305.26				
2.0 H_2O	aq			-305.60				
2.5 H_2O	aq			-305.98				
3 H_2O	aq			-306.23				
3.5 H_2O	aq			-306.43				
4 H_2O	aq			-306.60				
4.5 H_2O	aq			-306.75				
5 H_2O	aq			-306.87				
5.5 H_2O	aq			-306.97				
6 H_2O	aq			-307.05				
7 H_2O	aq			-307.20				
8 H_2O	aq			-307.31				
9 H_2O	aq			-307.40				
10 H_2O	aq			-307.48				
12 H_2O	aq			-307.594				
15 H_2O	aq			-307.715				
18 H_2O	aq			-307.793				
20 H_2O	aq			-307.831				

Table 19(5) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

PHOSPHORUS

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
H_3PO_4 in 25 H_2O	aq			-307.907				
30 H_2O	aq			-307.955				
40 H_2O	aq			-308.032				
50 H_2O	aq			-308.067				
75 H_2O	aq			-308.138				
100 H_2O	aq			-308.176				
150 H_2O	aq			-308.237				
200 H_2O	aq			-308.276				
250 H_2O	aq			-308.302				
300 H_2O	aq			-308.326				
350 H_2O	aq			-308.35				
400 H_2O	aq			-308.368				
500 H_2O	aq			-308.403				
750 H_2O	aq			-308.473				
1,000 H_2O	aq			-308.532				
1,500 H_2O	aq			-308.622				
2,000 H_2O	aq			-308.696				
2,500 H_2O	aq			-308.762				
3,000 H_2O	aq			-308.818				
4,000 H_2O	aq			-308.931				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 19(6) PHOSPHORUS

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
H_3PO_4 in 5,000 H_2O	aq			-308.982				
10,000 H_2O	aq			-309.197				
$H_3PO_4 \cdot 0.5\ H_2O$	c	107.0030	-336.899	-342.1	-296.9	4.785	30.87	20.12
$H_3PO_4 \cdot H_2O$	c	116.0106		-374.96				
PH_4OH std. state, m = 1	aq	52.0130		-70.48	-56.34		65.	
$HP_2O_7^{3-}$ std. state, m = 1	aq	174.9514		-543.7	-471.4		11.	
$H_2P_2O_7^{2-}$ std. state, m = 1	aq	175.9593		-544.6	-480.5		39.	
$H_3P_2O_7^{-}$ std. state, m = 1	aq	176.9673		-544.1	-483.6		51.	
$H_4P_2O_5$	aq	145.9765		-393.6				
$H_4P_2O_7$	c	177.9753		-535.6				
supercooled	liq			-533.4				
undissoc.; std. state, m = 1	aq			-542.2	-485.7		64.	
in 500 H_2O	aq			-543.0				
$H_4P_2O_7 \cdot 3/2\ H_2O$	c	204.9983		-640.9				
	liq			-637.3				
PF	g	49.9722				2.117	53.74	7.56
PF_3	g	87.9690	-218.25	-219.6	-214.5	3.092	65.28	14.03
PF_5	g	125.9658		-381.4				
PO_3F^{2-} std. state, m = 1	aq	97.9704			-280.8			

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 19(7) PHOSPHORUS

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
POF_3	g	103.9684	-287.39	-289.5	-277.9	3.369	68.11	16.41
HPO_3F^- std. state, m = 1	aq	98.9784			-286.4			
H_2PO_3F undissoc.; std. state, m = 1	aq	99.9863			-287.5			
PCl_3	liq	137.3328		-76.4	-65.1		51.9	
	g		-67.85	-68.6	-64.0	3.817	74.49	17.17
PCl_3^+	g		180.	181.				
PCl_5	c	208.2388		-106.0				
	g		-88.33	-89.6	-72.9	5.499	87.11	26.96
$POCl_3$	c	153.3322	-145.81					
	liq			-142.7	-124.5	8.720	53.17	33.17
	g		-132.15	-133.48	-122.60	4.273	77.76	20.30
in $CHCl_3$				-143.6				
PH_4Cl	c	70.4587		-34.7				
$H_3PO_4 \cdot HClO_4$	c	198.4539		-325.3				
PBr_3	liq	270.7008		-44.1	-42.0		57.4	
	g		-27.47	-33.3	-38.9	4.240	83.17	18.16
in CS_2				-43.0				
PBr_5	c	430.5188		-64.5				
$POBr_3$	c	286.7002		-109.6				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 19(8) PHOSPHORUS

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$POBr_3$	g					4.744	85.97	21.48
PH_4Br	c	114.9147		-30.5	-11.4		26.3	
PI_3	c	411.6870		-10.9				
	g					4.542	89.45	18.73
in CS_2				-7.6				
PH_4I	c	161.9101		-16.7	0.2		29.4	26.2
P_2S_3	c	158.1396		-19.2				
$PSCl_3$	g	169.3968				4.522	80.47	21.39
$PSBr_3$	c	302.7648					55.2	
	g						89.07	22.69
PN	g	44.9805	33.	32.76	27.47	2.080	50.45	7.10
$1/n\ (PN)_n$	c			-15.				
P_3N_5	c	162.9549		-71.4				36.
NH_4PO_3	aq	97.0106		-265.2				
$NH_4H_2PO_2$	c	83.0271		-180.0				

Table 19(9) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

PHOSPHORUS

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$NH_4H_2PO_2$ in 100 H_2O	aq			-178.00				
200 H_2O	aq			-178.16				
300 H_2O	aq			-178.22				
400 H_2O	aq			-178.28				
800 H_2O	aq			-178.32				
1,000 H_2O	aq			-178.34				
1,400 H_2O	aq			-178.38				
1,600 H_2O	aq			-178.39				
∞ H_2O	aq			-178.4				
$NH_4H_2PO_3$	aq	99.0265		-263.4				
$NH_4H_2PO_4$	c	115.0259		-345.38	-289.33		36.32	34.00
std. state, m = 1	aq			-341.49	-289.14		48.7	
in 15 H_2O	aq			-341.597				
20 H_2O	aq			-341.595				
25 H_2O	aq			-341.589				
40 H_2O	aq			-341.568				
50 H_2O	aq			-341.553				
75 H_2O	aq			-341.539				
100 H_2O	aq			-341.528				
200 H_2O	aq			-341.511				
500 H_2O	aq			-341.499				

Table 19(10) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

PHOSPHORUS

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$NH_4H_2PO_4$ in 1,000 H_2O	aq			-341.495				
5,000 H_2O	aq			-341.491				
∞ H_2O	aq			-341.49				
$(NH_4)_2HPO_3$	aq	116.0571		-249.9				
$(NH_4)_2HPO_4$	c	132.0565		-374.50				45.
std. state, m = 1	aq			-372.17	-298.28		46.2	
in 11 H_2O	aq			-370.35				
15 H_2O	aq			-370.40				
20 H_2O	aq			-370.48				
25 H_2O	aq			-370.56				
30 H_2O	aq			-370.62				
50 H_2O	aq			-370.85				
75 H_2O	aq			-371.00				
100 H_2O	aq			-371.22				
200 H_2O	aq			-371.29				
300 H_2O	aq			-371.35				
500 H_2O	aq			-371.4				
1,000 H_2O	aq			-371.44				
$(NH_4)_3PO_4$	c	149.0871		-399.6				
std. state, m = 1	aq			-400.3	-300.4		28.	

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Table 19(11) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — PHOSPHORUS

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$(NH_4)_3PO_4$ in 600 H_2O	aq	149.0871		-391.3				
$(NH_4)_3PO_4 \cdot 3H_2O$	c	203.1332		-610.8				
$NH_4H_3P_2O_7$ std. state, m = 1	aq	195.0059		-575.8	-502.6		78.	
$(NH_4)_2H_2P_2O_7$ std. state, m = 1	aq	212.0365		-607.9	-518.4		93.	
$(NH_4)_3HP_2O_7$ std. state, m = 1	aq	229.0671		-638.7	-528.3		92.	
$(NH_4)_4P_2O_7$ std. state, m = 1	aq	246.0977		-669.5	-534.6		80.	
NH_4PF_6	c	163.0028					60.49	40.33
$NH_4PF_6 \cdot NH_3$	c	180.0334					79.8	
NH_4HPO_3F std. state, m = 1	aq	117.0170			-305.4			
$(NH_4)_2PO_3F$ std. state, m = 1	aq	134.0476			-318.7			

Table 20(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

ARSENIC

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
As	α, gray, metallic	c	74.9216	0	0	0	1.226	8.4	5.89
	γ, yellow, cubic	c			3.5				
	β	amorp			1.0				
		g		72.04	72.3	62.4	1.481	41.61	4.968
As^+		g		298.38	300.12				
As^{2+}		g		764.42	767.64				
As^{3+}		g		1417.44	1422.14				
As^{4+}		g		2573.58	2579.76				
As^{5+}		g		4017.82	4025.48				
As^{6+}		g		6959.28	6968.42				
As_2		g	149.8432	53.30	53.1	41.1	2.251	57.2	8.366
As_4		g	299.6864		34.4	22.1		75.	
AsO		g	90.9210	16.88	16.72		2.101		
AsO^+	undissoc.; std. state, m = 1	aq				-39.15			
AsO_2^-	std. state, m = 1	aq	106.9204		-102.54	-83.66		9.9	
AsO_4^{3-}	std. state, m = 1	aq	138.9192		-212.27	-155.00		-38.9	
As_2O_4		c	213.8408		-189.72				
As_2O_5		c	229.8402		-221.05	-187.0		25.2	27.85
		aq			-227.4				
$As_2O_5 \cdot 4H_2O$		c	301.9016		-503.0				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 20(2) ARSENIC

Substance				ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description		State	Formula Weight	0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
As_4O_6	octahedral	c	395.6828		-314.04	-275.46		51.2	45.72
	monoclinic	c			-313.0	-275.82		56.	
		g			-289.0	-262.4		91.	
		aq			-299.6				
$3As_2O_5 \cdot 5H_2O$		c	779.5973		-1015.4				
AsH_3		g	77.9455	17.70	15.88	16.47	2.438	53.22	9.10
$HAsO_2$	undissoc.; std. state, m = 1	aq	107.9284		-109.1	-96.25		30.1	
$HAsO_4^{2-}$	undissoc.; std. state, m = 1	aq	139.9272		-216.62	-170.82		-0.4	
$H_2AsO_3^-$	undissoc.; std. state, m = 1	aq	124.9357		-170.84	-140.35		26.4	
$H_2AsO_4^-$	undissoc.; std. state, m = 1	aq	140.9351		-217.39	-180.04		28.	
H_3AsO_3	undissoc.; std. state, m = 1	aq	125.9437		-177.4	-152.94		46.6	
		aq			-177.4				
H_3AsO_4		c	141.9431		-216.6				
		aq			-216.2				
	undissoc.; std. state, m = 1	aq			-215.7	-183.1		44.	
AsF_3		liq	131.9168		-228.55	-217.29		43.31	30.25
		g		-219.06	-220.04	-216.46	3.413	69.07	15.68
AsO_3F^{2-}	undissoc.; std. state, m = 1	aq	141.9182			-245.59			

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 20(3) ARSENIC

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$HAsO_3F^-$	undissoc.; std. state, m = 1	aq	142.9262			-253.60			
$AsCl_2$		g	145.8276	16.	16.				
$AsCl_3$		liq	181.2806		-72.9	-61.37		49.6	
		g		-61.42	-61.80	-58.77	4.137	78.17	18.10
$AsBr_3$		c	314.6486		-47.2				
		g		-25.55	-31.	-38.	4.569	86.94	18.92
AsI_3		c	455.6348	-13.91	-13.9	-14.2	5.964	50.92	25.28
		g					4.834	92.79	19.27
As_2S_2		c	213.9712		-34.1				
As_2S_3		c	246.0352		-40.4	-40.3		39.1	27.8
$As_2O_3 \cdot SO_3$		c	277.9036		-285.45				
AsN		g	88.9283	47.	46.91	40.15	2.169	53.9	7.27
NH_4AsO_2	std. state, m = 1	aq	124.9590		-134.21	-102.63		37.0	
$NH_4H_2AsO_3$	std. state, m = 1	aq	143.9743		-202.51	-159.32		53.5	
$NH_4H_2AsO_4$		c	158.9737		-253.3	-199.1		41.12	36.13
	std. state, m = 1	aq			-249.06	-199.01		55.1	
	in 660 H_2O	aq			-249.1				
$(NH_4)_2HAsO_4$		c	176.0043		-282.4				
	std. state, m = 1	aq			-279.9	-208.7		53.8	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 20(4) ARSENIC

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$(NH_4)_2HAsO_4$ in 660 H_2O	aq			-279.8				
$(NH_4)_3AsO_4$	c	193.0349		-307.4				
std. state, m = 1	aq			-307.28	-211.91		42.4	
$(NH_4)_3AsO_4 \cdot 3H_2O$	c	247.0810		-517.9				

Table 21(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

ANTIMONY

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
Sb	III	c	121.75	0	0	0	1.410	10.92	6.03
	IV, explosive	amorp			2.54				
		g		62.63	62.7	53.1	1.481	43.06	4.97
Sb^+		g		261.91	263.46				
Sb^{2+}		g		643.1	646.1				
Sb^{3+}		g		1227.1	1231.6				
Sb^{4+}		g		2245.4	2251.4				
Sb^{5+}		g		3530.	3537.				
Sb^{6+}		g		6012.	6021.				
Sb_2		g	243.50	56.76	56.3	44.7	2.360	60.90	8.70
Sb_4		g	487.00	50.2	49.0	33.8	4.40	84.	
SbO		g	137.749	48.	47.67		2.122		
SbO^+	std. state, m = 1	aq				-42.33			
SbO_2^-	std. state, m = 1	aq	153.749			-81.32			
Sb_2O_3		aq	291.498		-164.9				
Sb_2O_4		c	307.498		-216.9	-190.2		30.4	27.39
Sb_2O_5		c	323.497		-232.3	-198.2		29.9	
		aq			-228.7				
Sb_4O_6	II, cubic	c	582.996		-344.3	-303.1		52.8	

Table 21(2) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

ANTIMONY

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
Sb_4O_6	I, orthorhombic	c			-338.7	-299.5		58.8	48.46
Sb_6O_{13}		c	938.492		-670.6				
SbH_3		g	124.774	36.625	34.681	35.31	2.502	55.61	9.81
$HSbO_2$	undissoc.; std. state, m = 1	aq	154.757		-116.6	-97.4		11.1	
$Sb(OH)_3$		c	172.772			-163.8			
	undissoc.; std. state, m = 1	aq			-184.9	-154.1		27.8	
H_3SbO_4		aq	188.772		-216.8				
$HSb(OH)_6$		aq	224.802		-353.4				
SbF		g	140.748	-11.	-11.29		2.171		7.97
SbF_3		c	178.745		-218.8				
	in 200 H_2O	aq			-217.7				
SbOF	undissoc.; std. state, m = 1	aq	156.748			-116.5			
H_3SbF_6		aq	238.764		-448.4				
$Sb(OH)_2F$	undissoc.; std. state, m = 1	aq	174.763			-173.2			
SbCl		g	157.203	-6.	-6.22		2.289		8.49
$SbCl_2$		g	192.656	-18.	-18.5				
$SbCl_3$		c	228.109		-91.34	-77.37		44.0	25.8

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 21(3) ANTIMONY

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$SbCl_3$	g		-74.57	-75.0	-72.0	4.269	80.71	18.33
$SbCl_5$	liq	299.015		-105.2	-83.7		72.	
	g		-93.70	-94.25	-79.91	6.341	96.04	28.95
in nitrobenzene				-115.6				
SbOCl	c	173.202		-89.4				
	g		-25.	-25.5				
$Sb_4O_5Cl_2$	c	637.903		-346.9				
$SbBr_3$	c	361.477		-62.0	-57.2		49.5	
	g		-41.03	-46.5	-53.5	4.727	89.09	19.17
in CS_2				-58.4				
SbI_3	c	502.463		-24.0				
	aq			-23.6				
Sb_2S_3 black	c	339.692		-41.8	-41.5		43.5	28.65
orange	amorp			-35.2				
$Sb_2S_4^{2-}$ std. state, m = 1	aq	371.756		-52.4	-23.8		-12.5	
$Sb_2(SO_4)_3$	c	531.685		-574.2				
Sb_2Te_3	c	626.30		-13.5	-13.2		56.	
SbN	g	135.757	64.	63.66		2.104		7.41

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 21(4) ANTIMONY

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
NH_4SbO_2 std. state, m = 1	aq	171.787			-100.29			
$SbF_3 \cdot NH_3$	c	195.776		-243.5				
$SbF_3 \cdot 2NH_3$	c	212.806		-266.6				
$SbF_3 \cdot 3NH_3$	c	229.837		-286.9				
$SbF_3 \cdot 4NH_3$	c	246.868		-305.5				
$SbF_3 \cdot 6NH_3$	c	280.929		-342.5				
$(NH_4)_2Sb_2S_4$ std. state, m = 1	aq	407.833		-115.7	-61.7		41.7	

Table 22(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity
BISMUTH

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Bi	c	208.980	0	0	0	1.536	13.56	6.10
	g		49.56	49.5	40.2	1.481	44.669	4.968
Bi^{+}	g		217.65	219.07				
Bi^{2+}	g		602.5	605.4				
Bi^{3+}	g		1192.0	1196.4				
std. state, m = 1	aq				19.8			
Bi^{4+}	g		2237.0	2242.9				
Bi^{5+}	g		3528.5	3535.9				
Bi^{6+}	g		5565.	5574.				
Bi_2	g	417.960	53.12	52.5		2.454		8.83
BiO	g	224.9794				2.150		7.81
BiO^{+} std. state, m = 1	aq				-35.0			
Bi_2O_3	c	465.9582		-137.16	-118.0		36.2	27.13
$Bi_6O_6^{6+}$ std. state, m = 1	aq	1349.8764			-220.6			
$BiOH^{2+}$ std. state, m = 1	aq	225.9874			-35.0			
BiO·OH	c	241.9868			-88.0			
$Bi(OH)_3$	c	260.0021		-170.0				
$Bi_6O_6(OH)_3^{3+}$ std. state, m = 1	aq	1400.8985			-379.6			
$Bi_6(OH)_{12}^{6+}$ std. state, m = 1	aq	1457.9684			-561.9			
$Bi_9(OH)_{20}^{7+}$ std. state, m = 1	aq	2220.9674			-951.5			

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 22(2) BISMUTH

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Bi_9(OH)_{21}^{6+}$ std. state, m = 1	aq	2237.9748			-1003.8			
$Bi_9(OH)_{22}^{5+}$ std. state, m = 1	aq	2254.9821			-1056.9			
BiCl	c	244.433		-31.2	-25.9		22.6	
$BiCl^{2+}$ std. state, m = 1	aq				-14.64			
$BiCl_2^+$ std. state, m = 1	aq	279.886			-49.1			
$BiCl_3$	c	315.339		-90.6	-75.3		42.3	25.
	g		-63.32	-63.5	-61.2	4.642	85.74	19.04
in 2N HCl	aq			-101.7				
$BiCl_4^-$ std. state, m = 1	aq	350.792			-115.1			
$BiCl_6^{3-}$ std. state, m = 1	aq	421.698			-178.51			
BiOCl	c	260.4324		-87.7	-77.0		28.8	
$Bi(OH)_2Cl$	c	278.4477			-128.71			
$BiBr^{2+}$ std. state, m = 1	aq	288.889			-8.1			
$BiBr_2^+$ std. state, m = 1	aq	368.798			-35.9			
$BiBr_3$	c	448.707						26.
std. state, m = 1	aq	448.707			-63.3			
$BiBr_4^-$ std. state, m = 1	aq	528.616			-90.2			
BiOBr	c	304.8884			-71.0			
BiI^{2+} std. state, m = 1	aq	335.8844			3.8			

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 22(3) BISMUTH

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
BiI_3	c	589.6932			-41.9			
BiI_4^- std. state, m = 1	aq	716.5976			-49.9			
BiS	g	241.044		43.	29.		68.	
BiS^+	g			229.				
Bi_2S_3	c	514.152		-34.2	-33.6		47.9	29.2
$Bi_2(SO_4)_3$	c	706.1448		-608.1				
BiSe	g	287.940		42.0				
BiTe	g	336.580		42.8				
Bi_2Te_3	c	800.760	-18.43	-18.5	-18.4	7.387	62.36	28.8
$BiONO_3$	c	286.9843			-67.0			
NH_4BiCl_4 std. state, m = 1	aq	368.8306			-134.1			
$NH_4BiCl_6^{2-}$ std. state, m = 1	aq	439.7366			-197.6			
$(NH_4)_3BiCl_6$ std. state, m = 1	aq	475.8137			-235.42			
NH_4BiBr_4 std. state, m = 1	aq	546.6546			-109.2			
NH_4BiI_4 std. state, m = 1	aq	734.6362			-68.9			
$BiAsO_4$	c	347.8992			-148.			

Table 23(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
C graphite, Acheson spectroscopic	c	12.0112	0	0	0	0.251	1.372	2.038
diamond	c		0.5797	0.4533	0.6930	0.125[a]	0.568	1.4615
	g		169.98	171.291	160.442	1.562	37.7597	4.9805
C^+	g		429.628	432.420				
C^{2+}	g		991.900	996.173				
C^{3+}	g		2095.98	2101.73				
C^{4+}	g		3583.23	3590.46				
C^{5+}	g		12625.1	12633.8				
C^{6+}	g		23924.	23934.				
CO	g	28.0106	-27.199	-26.416	-32.780	2.0716	47.219	6.959
std. state, m = 1	aq			-28.91	-28.66		25.0	
in CH_3COOH				-26.416	-28.15		31.7	
CO^+	g		295.9	298.16				
CO^{2+}	g		942.	945.5				
CO_2	g	44.0100	-93.963	-94.051	-94.254	2.2378	51.06	8.87
undissoc.; std. state, m = 1	aq			-98.90	-92.26		28.1	
in CH_3OH				-97.57				
in C_2H_5OH; std. state, $x_2 = 1$				-96.85	-91.32		31.8	
in CCl_4				-98.39				

[a] Relative to C, diamond

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(2) CARBON

Substance				ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
CO_2	in acetone; std. state, $x_2 = 1$				-98.37	-91.91		28.7	
	in benzene				-95.16				
CO_2^+		g		223.8	225.23				
CO_3^{2-}	std. state, m = 1	aq	60.0094		-161.84	-126.17		-13.6	
CH		g	13.0191	141.6	142.4				
CH^+		g		398.1	400.4				
CH_2		g	14.0271	93.9	93.7				
CH_2^+		g		333.6	334.9				
CH_3		g	15.0351	34.0	33.2				
CH_3^+		g		261.0	261.7				
CH_4		g	16.0430	-15.970	-17.88	-12.13	2.388	44.492	8.439
	std. state, m = 1	aq			-21.28	-8.22		20.0	
CH_4^+		g		277.1	276.7				
HCO		g	29.0185	-4.2	-4.12	-7.76	2.386	53.68	8.26
$HCOO^-$	std. state, m = 1	aq	45.0180		-101.71	-83.9		22.	-21.0
HCO_3^-	std. state, m = 1	aq	61.0174		-165.39	-140.26		21.8	
HCHO		g	30.0265	-27.1	-28.	-27.	2.394	52.26	8.46
	unhydrolyzed	aq			-35.9				
	in 60 H_2O	aq			-42.8				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(3) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
HCHO in 40 CH_3OH				-43.0				
$HCHO^+$	g		223.6	224.2				
1/2 $(HCOOH)_2$ formic acid dimer	g	46.0259		-97.54				
HCOOH	liq			-101.51	-86.38		30.82	23.67
	g			-90.48				
un-ionized; std. state, m = 1	aq			-101.68	-89.0		39.	
ionized; std. state, m = 1	aq			-101.71	-83.9		22.	-21.0
in 0.5 H_2O	aq			-101.633				
1 H_2O	aq			-101.699				
2 H_2O	aq			-101.715				
3 H_2O	aq			-101.697				
4 H_2O	aq			-101.681				
5 H_2O	aq			-101.667				
6 H_2O	aq			-101.657				
8 H_2O	aq			-101.645				
10 H_2O	aq			-101.642				
15 H_2O	aq			-101.641				
25 H_2O	aq			-101.643				
50 H_2O	aq			-101.654				
75 H_2O	aq			-101.661				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(4) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
HCOOH in 100 H_2O	aq			-101.666				
200 H_2O	aq			-101.674				
500 H_2O	aq			-101.678				
1,000 H_2O	aq			-101.681				
10,000 H_2O	aq			-101.685				
20,000 H_2O	aq			-101.687				
50,000 H_2O	aq			-101.690				
100,000 H_2O	aq			-101.697				
∞ H_2O	aq			-101.71				
$HCOOH^+$	g			165.80				
H_2CO_3 std. state, m = 1	aq	62.0253		-167.22	-148.94		44.8	
CH_3O^- in CH_3OH; std. state, m = 1		31.0345		-46.24	-16.96		-9.9	
CH_3OH	liq	32.0424		-57.04	-39.76		30.3	19.5
	g		-45.355	-47.96	-38.72	2.731	57.29	10.49
std. state, m = 1	aq			-58.779	-41.92		31.8	
in 0.25 H_2O	aq			-57.179				
0.5 H_2O	aq			-57.273				
1.0 H_2O	aq			-57.425				
1.5 H_2O	aq			-57.555				
2.0 H_2O	aq			-57.675				

Table 23(5) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	Cp°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CH_3OH in 2.5 H_2O	aq			-57.780				
3.0 H_2O	aq			-57.872				
3.5 H_2O	aq			-57.954				
4.0 H_2O	aq			-58.026				
4.5 H_2O	aq			-58.089				
5.0 H_2O	aq			-58.145				
5.5 H_2O	aq			-58.194				
6 H_2O	aq			-58.236				
7 H_2O	aq			-58.307				
8 H_2O	aq			-58.362				
9 H_2O	aq			-58.407				
10 H_2O	aq			-58.439				
12 H_2O	aq			-58.498				
15 H_2O	aq			-58.553				
20 H_2O	aq			-58.609				
25 H_2O	aq			-58.642				
30 H_2O	aq			-58.665				
40 H_2O	aq			-58.693				
50 H_2O	aq			-58.710				
75 H_2O	aq			-58.733				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(6) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CH_3OH in 100 H_2O	aq			-58.744				
150 H_2O	aq			-58.756				
200 H_2O	aq			-58.762				
300 H_2O	aq			-58.767				
400 H_2O	aq			-58.770				
500 H_2O	aq			-58.772				
1,000 H_2O	aq			-58.776				
∞ H_2O	aq			-58.779				
in 0.1 C_6H_6				-57.004				
0.15 C_6H_6				-56.986				
0.2 C_6H_6				-56.969				
0.25 C_6H_6				-56.952				
0.5 C_6H_6				-56.875				
1.0 C_6H_6				-56.742				
1.5 C_6H_6				-56.634				
2.0 C_6H_6				-56.532				
2.5 C_6H_6				-56.441				
3.0 C_6H_6				-56.359				
3.5 C_6H_6				-56.282				
4.0 C_6H_6				-56.208				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(7) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CH_3OH in 4.5 C_6H_6				-56.139				
5.0 C_6H_6				-56.074				
5.5 C_6H_6				-56.010				
6 C_6H_6				-55.950				
7 C_6H_6				-55.839				
8 C_6H_6				-55.738				
9 C_6H_6				-55.648				
10 C_6H_6				-55.562				
12 C_6H_6				-55.408				
15 C_6H_6				-55.212				
20 C_6H_6				-54.950				
in 10 $(CH_2OH)_2$				-56.960				
CH_3OH^+	g		204.8	203.7				
$CH_2(OH)_2$	g	48.0418		-98.				
	aq			-111.1				
CF_3	g	69.0064	-113.	-114.				
CF_3^+	g		119.9	120.4				
CF_4	g	88.0048	-219.6	-221.	-210.	3.043	62.50	14.60
in C_7F_{14}; std. state, $x_2 = 1$				-222.7	-207.3		47.6	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(8) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
COF_2	g	66.0074	-150.95	-151.7	-148.0	2.642	61.78	11.19
CH_3F	g	34.0335				2.422	53.25	8.96
CH_2F_2	g	52.0239	-104.97	-106.8	-100.2	2.555	58.94	10.25
CHF_3	g	70.0143	-162.84	-164.5	-156.3	2.764	62.04	12.20
CHOF	g	48.0169				2.486	58.92	9.54
CCl_3	g	118.3702	14.	14.				
CCl_3^+	g		216.5	218.0				
CCl_4	liq	153.8232		-32.37	-15.60		51.72	31.49
	g		-24.08	-24.6	-14.49	4.117	74.03	19.91
in 0.1 C_6H_6				-32.360				
0.25 C_6H_6				-32.348				
0.5 C_6H_6				-32.333				
1.0 C_6H_6				-32.315				
1.5 C_6H_6				-32.303				
2 C_6H_6				-32.295				
3 C_6H_6				-32.285				
4 C_6H_6				-32.278				
5 C_6H_6				-32.273				
6 C_6H_6				-32.270				
8 C_6H_6				-32.265				
10 C_6H_6				-32.261				

Table 23(9) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	Cp°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CCl_4 in CH_2Cl_2								
in 1 CH_2Cl_2				-32.09				
3 CH_2Cl_2				-31.94				
in $CHCl_3$								
in 0.1 $CHCl_3$				-32.350				
0.25 $CHCl_3$				-32.326				
0.5 $CHCl_3$				-32.296				
1.0 $CHCl_3$				-32.259				
1.5 $CHCl_3$				-32.237				
2 $CHCl_3$				-32.222				
3 $CHCl_3$				-32.203				
4 $CHCl_3$				-32.192				
5 $CHCl_3$				-32.185				
6 $CHCl_3$				-32.179				
8 $CHCl_3$				-32.172				
10 $CHCl_3$				-32.168				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(10) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CCl_4 in 2 CH_2BrCH_2Br				-32.05				
10 CH_2BrCH_2Br				-31.95				
in 2 CH_3I				-32.194				
10 CH_3I				-32.127				
in 2 CS_2				-32.16				
10 CS_2				-32.04				
CCl_4^+	g		240.4	241.4				
$COCl_2$	g	98.9166	-51.89	-52.3	-48.9	3.067	67.74	13.78
CH_3Cl	g	50.4881	-17.426	-19.32	-13.72	2.489	56.04	9.74
std. state, m = 1	aq			-24.3	-12.3		34.6	
CH_3Cl^+	g		242.7	242.3				
CH_2Cl_2	liq	84.9331		-29.03	-16.09		42.5	23.9
	g		-20.462	-22.10	-15.75	2.830	64.56	12.18
in 1 CCl_4				-28.75				
3 CCl_4				-28.62				
in 10 $CHCl_3$				-29.020				
in 2 CH_3I				-28.918				
10 CH_3I				-28.865				
$CH_2Cl_2^+$	g		241.3	241.1				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(11) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$CHCl_3$	liq	119.3781		-32.14	-17.62		48.2	27.2
	g		-23.486	-24.65	-16.82	3.389	70.65	15.70
in 1000 H_2O	aq			-34.3				
in 2 CH_3COCH_3				-33.22				
5 CH_3COCH_3				-33.28				
10 CH_3COCH_3				-33.30				
in 75 $(C_2H_5)_2O$				-34.10				
in 0.1 CCl_4				-32.120				
0.25 CCl_4				-32.096				
0.5 CCl_4				-32.066				
1.0 CCl_4				-32.029				
1.5 CCl_4				-32.007				
2 CCl_4				-31.992				
3 CCl_4				-31.973				
4 CCl_4				-31.962				
5 CCl_4				-31.955				
6 CCl_4				-31.949				
8 CCl_4				-31.942				
10 CCl_4				-31.938				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(12) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$CHCl_3$ in 2 CH_2CH_2				-32.129				
10 CH_2CH_2				-32.121				
in 2 CH_2BrCH_2Br				-32.21				
in 2 CH_3I				-32.246				
10 CH_3I				-32.268				
in C_4H_5N pyrrole				-32.430				
in C_9H_7N isoquinoline				-33.020				
in C_9H_7N quinoline				-33.110				
in C_5H_5N pyridine				-33.108				
in C_6H_7N α-picoline				-33.320				
in C_6H_7N β-picoline				-33.212				
in C_6H_7N γ-picoline				-33.252				
in C_7H_9N 2,4-lutidine				-33.686				
in C_7H_9N 2,6-lutidine				-33.694				
in $C_8H_{11}N$ collidine (2,4,6-trimethylpyridine)				-33.946				
in $C_4H_{11}N$ n-butylamine				-33.568				
in $C_8H_{19}N$ di-n-butylamine				-33.760				
in $C_4H_{11}N$ diethylamine				-33.912				
in $C_6H_{15}N$ di-isopropylamine				-34.010				
in $C_{12}H_{27}N$ tri-n-butylamine				-33.016				
in $C_6H_{15}N$ triethylamine				-33.880				

Table 23(13) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$CHCl_3^+$	g		239.9	240.2				
CF_3Cl	g	104.4594	-164.8	-166.	-156.	3.293	68.16	15.98
CF_3Cl^+	g		132.9	133.2				
CF_2Cl_2	g	120.9140	-113.0	-114.	-105.	3.543	71.86	17.27
$CF_2Cl_2^+$	g		170.9	171.4				
$CFCl_3$	liq	137.3686		-72.02	-56.61		53.86	29.05
	g		-65.2	-66.	-57.	3.843	74.05	18.66
$CFCl_3^+$	g		206.2	206.9				
COFCl	g					2.845	66.11	12.52
CH_2ClF	g	68.4785				2.689	63.17	11.24
$CHClF_2$	g	86.4689				2.955	67.11	13.35
$CHCl_2F$	g	102.9235				3.170	70.02	14.56
CBr_3	g		47.	42.				
CBr_3^+	g		227.	224.				
CBr_4 monoclinic	c	331.6472		4.5	11.4		50.8	34.5
	g		26.10	19.	16.	4.873	85.55	21.79
$COBr_2$	liq	187.8286		-30.4				
	g		-19.19	-23.0	-26.5	3.340	73.85	14.78
CH_3Br	g	94.9441	-4.72	-8.4	-6.2	2.536	58.86	10.14
in C_2H_5OH				-13.08				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(14) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CH_3Br^+	g		238.1	235.9				
CH_2Br_2	g	173.8451				3.020	70.06	13.07
$CHBr_3$	liq	252.7461		-6.8	-1.2		52.8	31.
	g		10.24	4.	2.	3.811	79.07	17.02
$CHBr_3^+$	g		252.6	247.9				
CF_3Br	g	148.9154	-150.72	-153.6	-147.3	3.457	71.14	16.57
CF_3Br^+	g		121.9	120.5				
CF_2Br_2	g	209.8260				3.892	77.71	18.41
$CFBr_3$	g	270.7366				4.364	82.64	20.17
COFBr	g	126.9180				2.980	69.25	13.14
CH_2BrF	g	112.9345				2.781	66.0	11.76
$CHBrF_2$	g	130.9249				3.147	70.5	14.04
$CHFBr_2$	g	191.8355				3.439	75.7	15.56
CCl_3Br	g	198.2792	-8.81	-11.0	-5.1	4.285	79.55	20.38
CBr_2Cl_2	g	242.7352				4.467	83.1	20.81
$CClBr_3$	g	287.1912				4.679	85.5	21.36
COClBr	g	143.3726				3.1979	72.126	14.280
CH_2ClBr	g	129.3891				2.919	68.7	12.60
$CHBrCl_2$	g	163.8341				3.520	75.6	16.11

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(15) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$CHBr_2Cl$	g	208.2901				3.655	78.3	16.53
CF_2ClBr	g	165.3700				3.708	76.1	17.82
$CFBrCl_2$	g	181.8246				3.994	79.0	19.13
$CFBr_2Cl$	g	226.2806				4.180	81.9	19.69
$CHFClBr$	g	147.3795				3.308	72.7	15.11
CI_4	g	519.6288				5.343	93.65	22.91
CH_3I	liq	141.9395		-3.7	3.2		39.0	30.
	g		5.38	3.1	3.5	2.585	60.71	10.54
in 2 CCl_4				-3.524				
10 CCl_4				-3.444				
in 2 CH_2Cl_2				-3.586				
10 CH_2Cl_2				-3.548				
in 2 $CHCl_3$				-3.815				
10 $CHCl_3$				-3.865				
CH_3I^+	g		225.4	224.6				
CH_2I_2	liq	267.8359		16.0	21.6		41.6	32.
	g		29.26	27.0	22.9	3.172	74.0	13.79
CHI_3	c	393.7323		33.7				
	g					4.106	85.1	17.92
CH_3I_3 in n-heptane		395.7483		-4.2				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(16) CARBON

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
CF_3I		g	195.9108				3.579	73.44	16.94
CH_2ClI		g	176.3845				3.002	70.7	13.02
CH_2IBr		g	220.8405				3.102	73.5	13.46
CS		g	44.0752	55.	56.	44.	2.081	50.30	7.12
CS_2		liq	76.1392		21.44	15.60		36.17	18.1
		g		27.86	28.05	16.05	2.547	56.82	10.85
		aq			21.3				
	in 2 C_6H_6				21.782				
	10 C_6H_6				21.888				
	in 2 CCl_4				21.64				
	10 CCl_4				21.69				
	in 2 CH_2BrCH_2Br				21.90				
	10 CH_2BrCH_2Br				22.00				
CS_2^+		g		260.4	262.0				
COS		g	60.0746	-33.991	-33.96	-40.47	2.373	55.32	9.92
COS^+		g		225.0	226.5				
CH_3SH		liq	48.1070		-11.08	-1.85		40.44	21.64
		g		-2.885	-5.34	-2.23	2.898	60.96	12.01
$SC(SH)_2$	trithiocarbonic acid	liq	110.2191		6.0	7.0		52.	35.8
CH_2SO_4	methylene sulfate	c	110.0887		-164.6				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(17) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
HF·COS	g	80.0809		-102.6				
$CSCl_2$	g					3.416	71.51	15.18
CSe_2	liq	169.9312		39.4				
CN	g	26.0178	108.	109.	102.	2.07	48.4	6.97
CN^+	g		435.5	438.0				
CN^- std. state, m = 1	aq			36.0	41.2		22. 5	
N_3CN cyanogen azide	c	68.0380		92.6				
$1/n(N_3CN)_n$ polymeric	c			82.2				
CNO^- std. state, m = 1	aq	42.0172		-34.9	-23.3		25.5	
$C(NO_2)_4$	liq	196.0332		8.8				
HCN	liq	27.0258		26.02	29.86		26.97	16.88
	g		32.39	32.3	29.8	2.208	48.20	8:57
std. state, m = 1	aq			36.0	41.2		22.5	
un-ionized; std. state, m = 1	aq			25.6	28.6		29.8	
HCN^+	g		353.2	354.6				
CH_3NH_2 methylamine	liq	31.0577		-11.3	8.5		35.90	
	g			-5.49	7.67		58.15	12.7
std. state, m = 1	aq			-16.77	4.94		29.5	
in 300 H_2O	aq			-16.57				
400 H_2O	aq			-16.62				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(18) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CH_3NH_2 in 500 H_2O	aq			-16.65				
600 H_2O	aq			-16.67				
700 H_2O	aq			-16.70				
800 H_2O	aq			-16.73				
900 H_2O	aq			-16.76				
1000 H_2O	aq			-16.78				
$CH_3NH_2^+$	g			202.9				
$CH_3NH_3^+$ std. state, m = 1	aq	32.0657		-29.86	-9.55		34.1	
CH_2N_2 diazirine	g	42.0405				2.513	56.87	10.19
CH_2N_2 diazomethane	g					2.887	58.02	12.55
NH_2CN cyanamide	c			14.1				
in 600 H_2O	aq			17.8				
NH_4CN	c	44.0564		0.10				32.
std. state, m = 1	aq			4.3	22.2		49.6	
	aq			7.7				
CH_3NHNH_2	liq	46.0724		12.9	43.0		39.66	32.25
	g		27.506	22.55	44.66	3.438	66.61	17.0
$C{=}NH(NH_2)_2$ guanidine	c	59.0711		-18.1				
CH_2N_4 tetrazole	c	70.0539		56.7				
in 700 acetone				59.74				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(19) CARBON

Substance				ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
CH_3N_5	5-aminotetrazole	c	85.0686		49.7				
HNCO	isocyanic acid	g	43.0252				2.615	56.85	10.72
HCNO	cyanic acid, std. state, m = 1, ionized	aq			-34.9	-23.3		25.5	
	un-ionized, std. state, m = 1	aq			-36.90	-28.0		34.6	
$CH_2NO_2^-$	nitromethane ion of nitro form	aq	60.0326		-20.3				
$HCONH_2$		liq	45.0412		-60.7				
		g					2.575	59.41	10.84
	in 200 H_2O	aq			-59.2				
CH_3NO_2	nitromethane	liq	61.0406		-27.03	-3.47		41.05	25.33
		g		-14.546	-17.86	-1.65	3.083	65.69	13.70
	in 600 H_2O	aq			-26.4				
CH_3ONO	methyl nitrite	g	61.0406		-16.5				
$CH_3NO_2^+$		g		241.0	239.1				
CH_3NO_3		liq	77.0400	-38.82	-38.0	-10.4	8.26	51.9	37.6
		g			-29.8	-9.4		76.1	
$HCOONH_4$		c	63.0565		-135.63				
	std. state, m = 1	aq			-133.38	-102.9		49.	-1.9
	in 200 H_2O	aq			-133.15				
NH_4HCO_3		c	79.0559		-203.0	-159.2		28.9	
	std. state, m = 1	aq			-197.06	-159.23		48.9	
		aq			-196.4				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(20) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CH_3NH_3OH std. state, m = 1	aq	49.0730		-84.83	-47.14		31.5	
un-ionized, std. state, m = 1	aq			-85.08	-51.75		46.2	
NH_4CNO	c	60.0558		-72.75				
std. state, m = 1	aq			-66.6	-42.3		52.6	
$CO(NH_2)_2$ urea	c	60.0558		-79.56	-47.04		25.00	22.26
in 3.0 H_2O	aq			-76.610				
3.5 H_2O	aq			-76.566				
4.0 H_2O	aq			-76.528				
4.5 H_2O	aq			-76.494				
5.0 H_2O	aq			-76.466				
5.5 H_2O	aq			-76.440				
6 H_2O	aq			-76.418				
7 H_2O	aq			-76.376				
8 H_2O	aq			-76.340				
9 H_2O	aq			-76.310				
10 H_2O	aq			-76.286				
15 H_2O	aq			-76.200				
20 H_2O	aq			-76.150				
25 H_2O	aq			-76.117				
50 H_2O	aq			-76.042				

Table 23(21) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$CO(NH_2)_2$ urea								
in 75 H_2O	aq			-76.014				
100 H_2O	aq			-76.00				
150 H_2O	aq			-75.985				
200 H_2O	aq			-75.978				
400 H_2O	aq			-75.966				
∞ H_2O	aq			-75.954				
in 125 CH_3OH				-77.37				
in 85 C_2H_5OH				-76.50				
in 65 C_3H_7OH				-76.82				
NH_2COONH_4 ammonium carbamate	c	78.0712		-154.17	-107.09		31.9	
	aq			-150.4				
$CH_3NH_3NO_3$ methylammonium nitrate	c	94.0706		-84.7				
std. state, m = 1	aq			-79.43	-36.16		69.1	
in 500 H_2O	aq	94.0706		-79.3				
$(NH_4)_2CO_3$ std. state, m = 1	aq	96.0865		-225.18	-164.11		40.6	
in 400 H_2O	aq			-218.3				
$CH(NO_2)_3$	liq	151.0356		-5.1				
$NH_2CONHNO_2$ nitrourea	c	105.0534		-67.5				
$NH_2CONHNH_2$ semicarbazide, std. state, m = 1	aq	75.0705		-39.9	-9.7		71.2	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(22) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$CO(NH_2)_2 \cdot HNO_3$ urea nitrate	c	123.0687		-134.8				
in 400 H_2O	aq			-124.3				
$CO(NH_2)_2 \cdot NH_3$ urea ammine	c	77.0864		-98.5				
CH_2N_4O 5-hydroxytetrazole	c	86.0533		1.5				
$CH_4N_4O_2$ nitroguanidine	c	104.0686		-22.13				
$C{=}NH(NH_2)_2 \cdot HNO_3$ guanidine nitrate	c	122.0840		-92.5				
in 1600 H_2O	aq			-83.0				
$CH_5N_5O_2$ nitroaminoguanidine	c	119.0833		5.3				
$CH_2N_6O_2$ nitroguanylazide	c	130.0661		71.3				
$CH_4N_6O_3$ 5-aminotetrazole nitrate	c	148.0814		-6.6				
$CH_4N_6O_3$ guanylazide nitrate	c			3.8				
$CH_8N_6O_3$ diaminoguanidine nitrate	c	152.1133		-37.6				
CNF	g	45.0162				2.422	53.67	9.99
CNCl	liq	61.4708		26.79				
	g		32.804	32.97	31.32	2.550	56.42	10.75
$CCl(NO_2)_3$ trinitrochloromethane	liq	185.4806		-5.6				39.0
CH_3NH_3Cl methylamine hydrochloride	c	67.5187		-71.20	-37.99		33.13	21.72
std. state, m = 1	aq			-69.82	-40.92		47.6	
in 50 H_2O	aq			-69.650				
75 H_2O	aq			-69.665				
100 H_2O	aq			-69.674				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(23) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CH_3NH_3Cl in 150 H_2O	aq			-69.686				
200 H_2O	aq			-69.694				
300 H_2O	aq			-69.704				
400 H_2O	aq			-69.712				
500 H_2O	aq			-69.72				
600 H_2O	aq			-69.724				
700 H_2O	aq			-69.728				
800 H_2O	aq			-69.732				
900 H_2O	aq			-69.735				
1,000 H_2O	aq			-69.738				
1,500 H_2O	aq			-69.749				
2,000 H_2O	aq			-69.756				
3,000 H_2O	aq			-69.767				
4,000 H_2O	aq			-69.772				
5,000 H_2O	aq			-69.776				
7,000 H_2O	aq			-69.781				
10,000 H_2O	aq			-69.787				
20,000 H_2O	aq			-69.794				
50,000 H_2O	aq			-69.803				
100,000 H_2O	aq			-69.807				
∞ H_2O	aq			-69.817				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(24) CARBON

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$NH_2CONHNH_2 \cdot HCl$ semicarbazide hydrochloride		c	111.5315						34.
$C{=}NH(NH_2)_2 \cdot HClO_4$ guanidine perchlorate		c	159.5297		-74.8				
		aq			-64.4				
CNBr		c	105.9268		33.58				
		g		46.07	44.5	39.5	2.648	59.32	11.22
CNI		c	152.9222		39.71	44.22		23.0	
		g		54.04	53.9	47.0	2.724	61.35	11.54
	std. state, m = 1	aq			42.5	44.95		29.9	
	in CCl_4, std. state, m = 1					46.24			
I_2CN^-	std. state, m = 1	aq	279.8266			32.53			
CNS^-	thiocyanate ion std. state, m = 1	aq	58.0818		18.27	22.15		34.5	-9.6
NOSCN	std. state, m = 1	aq	88.0880		55.2	63.5		51.2	
HNCS	isothiocyanic acid	g	59.0898		30.5	27.0		59.2	11.2
HCNS	thiocyanic acid, undissoc. std. state, m = 1	aq				23.31			
	ionized; std. state, m = 1	aq			18.27	22.15		34.5	-9.6
	in 100 H_2O	aq			18.4				
NH_4CNS	ammonium thiocyanate	c	76.1204		-18.8				
	std. state, m = 1	aq			-13.40	3.18		61.6	9.5
	in 200 H_2O	aq			-13.4				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(25) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$CS(NH_2)_2$ thiourea	c	76.1204		-21.1				
in 100 H_2O	aq			-15.6				
$NH{=}CSS^{2-}$ std. state, m = 1	aq	91.1538		17.4				
NH_2CSS^- std. state, m = 1	aq	92.1618		7.5				
NH_2CSSH dithiocarbamic acid	aq	93.1698		7.2				
NH_2CSSNH_4 ammonium dithiocarbamate	c	110.2004		-30.3				
in 5000 H_2O	aq			-23.65				
$NH_4CNS \cdot SO_2$	c	140.1832		-98.7				
$CS(NH_2)_2 \cdot HNO_3$ thiourea nitrate	c	139.1333		-73.1				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(26) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
C_2	g							
C_2^+	g							
$C_2O_4^{2-}$ std. state, m = 1	aq	88.0199		-197.2	-161.1		10.9	
C_2H^+	g	25.0303	399.8	401.8				
C_2H_2	g	26.0382	54.324	54.19	50.00	2.392	48.00	10.50
std. state, m = 1	aq			50.54	51.88		29.5	
$C_2H_2^+$	g		317.4	318.8				
$C_2H_3^+$	g	27.0462						
C_2H_4	g	28.0542	14.515	12.49	16.28	2.525	52.45	10.41
std. state, m = 1	aq			8.69	19.43		29.2	
in $(C_2H_5)_2SO_4$ std. state, $x_2 = 1$				10.29	19.00		36.0	
$C_2H_4^+$	g							
C_2H_5 ethyl radical	g	29.0622	28.	25.	31.		59.2	
$C_2H_5^+$	g		222.	220.				
C_2H_6	g	30.0701	-16.523	-20.24	-7.86	2.856	54.85	12.58
std. state, m = 1	aq			-24.40	-4.09		28.3	
in $i\text{-}C_8H_{18}$, std. state, $x_2 = 1$				-23.22	-5.77		37.9	
in $(C_4F_9)_3N$, std. state, $x_2 = 1$				-22.74	-5.84		39.7	
$C_2H_6^+$	g		252.2	250.0				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(27) CARBON

Substance				ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$HC_2O_4^-$	std. state, m = 1	aq	89.0279		-195.6	-166.93		35.7	
CH_2CO	ketene	g	42.0376	-13.86	-14.6	-14.8	2.819	59.16	12.37
$(CHO)_2$	glyoxal	c	58.0370		-84.2				
	in 200 H_2O	aq			-82.7				
$(COOH)_2$	oxalic acid	c	90.0358		-197.7				28.
	std. state, m = 1	aq			-197.2	-161.1		10.9	
	in 300 H_2O	aq			-195.66				
	400 H_2O	aq			-195.69				
	500 H_2O	aq			-195.71				
	1,000 H_2O	aq			-195.76				
	2,000 H_2O	aq			-195.80				
	5,000 H_2O	aq			-195.84				
	10,000 H_2O	aq			-195.87				
	in CH_3OH				-196.8				
	in C_2H_5OH				-196.4				
	in C_3H_7OH				-195.8				
$(COOH)_2 \cdot 2H_2O$		c	126.0665		-341.0				
CH_3CO	acetyl radical	g	43.0456		-4.5				
CH_3COO^-	std. state, m = 1	aq	59.0450		-116.16	-88.29		20.7	-1.5
C_2H_4O	ethylene oxide	liq	44.0536		-18.60	-2.83		36.77	21.02
		g		-9.589	-12.58	-3.12	2.596	57.94	11.45
		aq			-20.1				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(28) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CH_3CHO acetaldehyde	liq			-45.96	-30.64		38.3	
	g		-37.14	-39.72	-30.81	3.01	59.8	13.7
in 1000 H_2O	aq			-50.35				
unhydrated; in 1000 H_2O	aq			-47.58				
1/3 $(CH_3CHO)_3$ paraldehyde	liq			-54.73				
1/4 $(CH_3CHO)_4$ metaldehyde	c			-56.2				
CH_3CHO^+	g		198.6	197.5				
$HCOOCH_3$ methyl formate	liq	60.0530		-90.60				29.
	g			-83.7				
in 100 H_2O	aq			-91.7				
CH_3COOH acetic acid	liq	60.0530		-115.8	-93.2		38.2	29.7
	g		-99.972	-103.31	-89.4	3.286	67.5	15.9
ionized; std. state, m = 1	aq			-116.16	-88.29		20.7	-1.5
un-ionized; std. state, m = 1	aq			-116.10	-94.78		42.7	
in 0.5 H_2O	aq			-115.665				
1.0 H_2O	aq			-115.642				
1.5 H_2O	aq			-115.628				
2.0 H_2O	aq			-115.632				
2.5 H_2O	aq			-115.654				
3.0 H_2O	aq			-115.672				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(29) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	$\bar{C}_p^\circ$
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CH_3COOH in 4.0 H_2O	aq			-115.698				
4.5 H_2O	aq			-115.707				
5 H_2O	aq			-115.715				
6 H_2O	aq			-115.731				
7 H_2O	aq			-115.749				
8 H_2O	aq			-115.768				
9 H_2O	aq			-115.787				
10 H_2O	aq			-115.807				
12 H_2O	aq			-115.842				
15 H_2O	aq			-115.883				
20 H_2O	aq			-115.927				
25 H_2O	aq			-115.956				
30 H_2O	aq			-115.977				
40 H_2O	aq			-116.005				
50 H_2O	aq			-116.013				
75 H_2O	aq			-116.047				
100 H_2O	aq			-116.059				
150 H_2O	aq			-116.072				
200 H_2O	aq			-116.078				
300 H_2O	aq			-116.084				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(30) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CH_3COOH in 500 H_2O	aq			-116.090				
1,000 H_2O	aq			-116.095				
10,000 H_2O	aq			-116.102				
20,000 H_2O	aq			-116.105				
50,000 H_2O	aq			-116.107				
100,000 H_2O	aq			-116.110				
∞ H_2O	aq			-116.16				
in CH_3COCH_3								
5 CH_3COCH_3				-116.45				
10 CH_3COCH_3				-116.54				
15 CH_3COCH_3				-116.61				
25 CH_3COCH_3				-116.70				
50 CH_3COCH_3				-116.78				
in 5 $(C_2H_5)_2O$				-115.84				
10 $(C_2H_5)_2O$				-115.83				
15 $(C_2H_5)_2O$				-115.82				
in 5 C_6H_6				-115.3				
10 C_6H_6				-115.1				
15 C_6H_6				-115.0				
25 C_6H_6				-114.8				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(31) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
1/2 $(CH_3COOH)_2$ acetic acid dimer	g			-110.95				
CH_3COOH^+	g		139.1	137.3				
$CH_2OHCOOH$ hydroxyacetic acid (glycolic acid)	c	76.0524		-158.7				
in 5 H_2O	aq			-156.04				
6 H_2O	aq			-155.96				
8 H_2O	aq			-155.89				
10 H_2O	aq			-155.84				
15 H_2O	aq			-155.78				
25 H_2O	aq			-155.72				
50 H_2O	aq			-155.67				
100 H_2O	aq			-155.64				
200 H_2O	aq			-155.62				
400 H_2O	aq			-155.6				
$CH(OH)_2COOH$ dihydroxyacetic acid (glyoxylic acid)	c	92.0518		-199.7				
in 100 H_2O	aq			-196.9				
$CH_3CH_2O^-$ std. state, m = 1	aq	45.0616			-24.5			
C_2H_5OH ethanol	liq	46.0695		-66.37	-41.80		38.4	26.64
	g		-51.969	-56.19	-40.29	3.390	67.54	15.64
std. state, m = 1	aq			-68.9	-43.44		35.5	

Table 23(32) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
C_2H_5OH in 0.25 H_2O	aq			-66.438				
0.5 H_2O	aq			-66.477				
1.0 H_2O	aq			-66.587				
1.5 H_2O	aq			-66.716				
2.0 H_2O	aq			-66.843				
2.5 H_2O	aq			-66.962				
3.0 H_2O	aq			-67.072				
3.5 H_2O	aq			-67.178				
4.0 H_2O	aq			-67.278				
4.5 H_2O	aq			-67.373				
5.0 H_2O	aq			-67.465				
5.5 H_2O	aq			-67.551				
6 H_2O	aq			-67.630				
7 H_2O	aq			-67.769				
8 H_2O	aq			-67.887				
9 H_2O	aq			-67.980				
10 H_2O	aq			-68.063				
12 H_2O	aq			-68.187				
15 H_2O	aq			-68.334				
20 H_2O	aq			-68.467				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(33) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
C_2H_5OH in 25 H_2O	aq			-68.555				
30 H_2O	aq			-68.614				
40 H_2O	aq			-68.690				
50 H_2O	aq			-68.740				
75 H_2O	aq			-68.804				
100 H_2O	aq			-68.836				
200 H_2O	aq			-68.888				
500 H_2O	aq			-68.893				
1000 H_2O	aq			-68.897				
∞ H_2O	aq			-68.9				
in 5 H_2SO_4				-77.97				
10 H_2SO_4				-78.60				
15 H_2SO_4				-78.87				
20 H_2SO_4				-79.03				
25 H_2SO_4				-79.15				
30 H_2SO_4				-79.25				
50 H_2SO_4				-79.53				
in 0.1 C_6H_6				-66.334				
0.15 C_6H_6				-66.312				
0.2 C_6H_6				-66.292				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(34) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
C_2H_5OH in 0.25 C_6H_6				-66.270				
0.5 C_6H_6				-66.090				
1.0 C_6H_6				-66.016				
1.5 C_6H_6				-65.872				
2.0 C_6H_6				-65.750				
2.5 C_6H_6				-65.644				
3.0 C_6H_6				-65.549				
3.5 C_6H_6				-65.464				
4.0 C_6H_6				-65.388				
4.5 C_6H_6				-65.316				
5.0 C_6H_6				-65.250				
5.5 C_6H_6				-65.188				
6 C_6H_6				-65.125				
7 C_6H_6				-65.005				
8 C_6H_6				-64.890				
9 C_6H_6				-64.782				
10 C_6H_6				-64.686				
12 C_6H_6				-64.518				
15 C_6H_6				-64.318				
20 C_6H_6				-64.050				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(35) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
C_2H_5OH in 25 C_6H_6				-63.860				
30 C_6H_6				-63.705				
40 C_6H_6				-63.455				
50 C_6H_6				-63.290				
75 C_6H_6				-63.050				
100 C_6H_6				-62.918				
in 2 CH_3CN				-66.022				
10 CH_3CN				-66.219				
$C_2H_5OH^+$	g		189.7	187.0				
$(CH_3)_2O$ dimethyl ether	g		-39.745	-43.99	-26.93	3.366	63.64	15.39
in 500 H_2O	aq			-52.2				
$CH_3OCH_3^+$	g		190.8	188.1				
$CH_3CH(OH)_2$ in 1000 H_2O	aq	62.0689		-120.99				
CH_3CH_2OOH ethyl hydrogen peroxide	liq			-58.				
$(CH_2OH)_2$ ethylene glycol	liq			-108.70	-77.25		39.9	35.8
in 0.1 H_2O	aq			-108.74				
0.2 H_2O	aq			-108.78				
0.3 H_2O	aq			-108.82				
0.5 H_2O	aq			-108.88				
0.7 H_2O	aq			-108.94				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(36) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$(CH_2OH)_2$ in 1.0 H_2O	aq			-109.01				
1.5 H_2O	aq			-109.12				
2.0 H_2O	aq			-109.22				
2.5 H_2O	aq			-109.30				
3.0 H_2O	aq			-109.37				
3.5 H_2O	aq			-109.43				
4.0 H_2O	aq			-109.49				
4.5 H_2O	aq			-109.54				
5.0 H_2O	aq			-109.59				
5.5 H_2O	aq			-109.64				
6 H_2O	aq			-109.68				
7 H_2O	aq			-109.71				
8 H_2O	aq			-109.80				
9 H_2O	aq			-109.85				
10 H_2O	aq			-109.89				
12 H_2O	aq			-109.96				
15 H_2O	aq			-110.04				
in 10 CH_3OH				-108.556				
$(CH_2OH)_2 \cdot 2H_2O$	c	98.0996		-245.8				
$(CH_2OH)_2O$	g	78.0683		-138.				
	aq			-154.7				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(37) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$(CH_2OH)_2O_2$ bishydroxymethyl peroxide	c	94.0677		-160.				
	g			-138.				
in 500 H_2O	aq			-155.				
C_2F_4 tetrafluorethylene	g	100.0159	-154.68	-155.5	-147.2	3.903	71.69	19.23
1/n $(C_2F_4)_n$ teflon; stable form at 25 °C	c			-196.1				
$C_2F_4^+$	g		78.7	79.4				
C_2F_6 hexafluoroethane	g	138.0127	-308.0	-310.	-290.	4.87	79.4	25.5
$CH{\equiv}CF$	g	44.0287				2.739	55.34	12.52
$CH_2{=}CHF$	g	46.0446				2.712	60.38	12.06
CH_3CH_2F ethyl fluoride	g	48.0606				3.06	63.2	14.0
$CHF{=}CHF$ cis 1,2-difluoroethylene	g	64.0350				3.022	64.09	13.91
$CH_2{=}CF_2$	g		-76.95	-78.6	-73.0	2.980	63.6	14.36
1/n$(CH_2{=}CF_2)_n$ vinylidene fluoride polymer	c			-114.58				
$CH_2{=}CF_2^+$	g	64.0350	160.6	160.4				
CH_3CHF_2	g	66.0510	-110.98	-114.3	-100.6	3.34	67.5	16.2
CH_3CF_3 1,1,1-trifluoroethane	g	84.0414	-172.93	-176.0	-159.5	3.631	66.87	18.69
CHF_2CH_2F	g			-174.7				
CF_3CH_2F	g	102.0318				4.079	75.85	20.82
CH_3COF acetyl fluoride	liq	62.0440		-110.83				
	g			-104.9				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(38) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)			
				kcal/mol			cal/deg mol	
CFH_2COOH	fluoroacetic acid	c	78.0434		-164.5			
CH_2FCH_2OH	2-fluoroethanol	liq	64.0600		-111.3			
CHF_2COOH	difluoroacetic acid	liq	96.0338		-207.8			
CHF_2CH_2OH	2,2-difluoroethanol	liq	82.0504		-164.8			
CF_3CH_2OH	2,2,2-trifluoroethanol	liq	100.0408		-205.4			
C_2Cl_4	tetrachloroethylene	liq	165.8343		-12.5	1.1	63.8	33.7
		g		-2.70	-2.9	5.4	4.686	81.5	22.69
$C_2Cl_4^+$		g		212.2	213.5			
C_2Cl_6	I, cubic	c	236.7403		-46.0			
	II, monoclinic	c			-47.9			
	III, triclinic	c			-48.5			
		g		-33.33	-33.9	-13.8	6.51	95.3	32.7
$(COCl)_2$	trans - oxalyl chloride	g	126.9271				4.527	79.3	21.71
CCl_3COO^-		aq	162.3801		-123.4			
CCl_3COCl	trichloroacetylchloride	liq	181.8337		-66.65			
$CH{\equiv}CCl$		g	60.4833				2.817	57.81	12.98
$CH_2{=}CHCl$	vinyl chloride	liq	62.4992		3.5			
		g		10.31	8.5	12.4	2.825	63.07	12.84
$1/n(CH_2{=}CHCl)_n$	polyvinyl chloride	c			-22.5				14.2
$CH_2{=}CHCl^+$		g		240.8	240.5			

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(39) CARBON

Substance				ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
C_2H_5Cl	ethyl chloride	liq	64.5152		-32.63	-14.20		45.60	24.94
		g		-23.331	-26.81	-14.45	3.179	65.94	15.01
$C_2H_5Cl^+$		g		229.9	227.9				
$CH_2{=}CCl_2$	1,1-dichloroethylene	c	96.9442	-7.87					
		liq			-5.8	5.85	6.787	48.17	26.60
		g		2.008	0.58	6.01	3.291	69.04	16.03
$1/n(CH_2{=}CCl_2)_n$	poly-1,1-dichloroethylene	c			-24.0				
CHCl=CHCl	cis-1,2-dichloroethylene	liq			-6.6	5.27		47.42	27.
	trans-1,2-dichloroethylene	liq			-5.53	6.52		46.81	27.
	cis-1,2-dichloroethylene	g		2.330	0.90	6.28	3.289	69.19	15.55
	trans-1,2-dichloroethylene	g		2.762	1.47	6.82	3.427	69.29	15.93
	cis in 2 trans-CHCl=CHCl				-6.498				
	10 trans-CHCl=CHCl				-6.386				
	trans in 2 cis-CHCl=CHCl				-5.449				
	10 cis-CHCl=CHCl				-5.434				
$CHCl{=}CHCl^+$	cis-1,2-dichloroethylene	g		224.9	224.9				
	trans-1,2-dichloroethylene	g		225.3	225.5				
CH_3CHCl_2	1,1-dichloroethane	liq	98.9602		-38.3	-18.1		50.61	30.18
		g		-27.870	-30.93	-17.35	3.683	72.90	18.22
CH_2ClCH_2Cl	1,2-dichloroethane	liq			-39.49	-19.03		49.84	30.9
		g		-28.357	-31.02	-17.67	4.08	73.68	18.8

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(40) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CH_2ClCH_2Cl in 1 C_6H_6				-39.460				
5 C_6H_6				-39.464				
$CH_2ClCH_2Cl^+$	g		228.0	226.9				
$CHCl{=}CCl_2$ trichloroethylene	liq	131.3893		-10.1	2.9		54.6	28.8
	g		-1.032	-1.86	4.31	3.975	77.6	19.18
$CHCl{=}CCl_2^+$	g		216.9	217.5				
CH_3CCl_3 1,1,1-trichloroethane	liq	133.4052					54.36	34.45
	g					4.39	77.2	22.3
$CHCl_2CH_2Cl$ 1,1,2-trichloroethane	liq			-43.5	-21.5		55.60	
	g		-31.386	-33.94	-19.35	4.273	80.57	21.27
CCl_3CH_2Cl 1,1,1,2-tetrachloroethane	g	167.8502				4.887	85.07	24.55
$CHCl_2CHCl_2$ 1,1,2,2-tetrachloroethane	liq			-47.0	-22.7		59.0	39.6
	g		-33.66	-35.7	-19.6	4.872	86.69	24.09
$CHCl_2CCl_3$ pentachloroethane	liq	202.2953		-44.9				46.7
	g					5.567	90.95	28.14
in 2 C_6H_6				-45.23				
10 C_6H_6				-45.06				
in 2 CH_3COCH_3				-46.08				
10 CH_3COCH_3				-46.33				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(41) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$CHCl_2CCl_3$ in 1 $(C_2H_5)_2O$				-46.33				
150 $(C_2H_5)_2O$				-46.88				
CH_2ClCOO^-	aq	93.4900		-119.813				
CH_3COCl acetyl chloride	liq	78.4986		-65.44	-49.73		48.0	28.
	g		-56.054	-58.20	-49.20	3.53	70.5	16.2
CH_3COCl^+	g		198.0	197.4				
CH_2ClCHO monochloroacetaldehyde	liq			-61.5				
$CH_2ClCOOH$ monochloroacetic acid, I	c	94.4980		-122.3				
II	c			-122.12				
III	c			-121.46				
ionized	aq			-119.813				
un-ionized; std. state, m = 1	aq			-118.643				
in 1,000 H_2O	aq			-118.92				
1,500 H_2O	aq			-118.923				
2,000 H_2O	aq			-118.935				
3,000 H_2O	aq			-118.964				
4,000 H_2O	aq			-118.990				
5,000 H_2O	aq			-119.014				
7,000 H_2O	aq			-119.056				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(42) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$CH_2ClCOOH$ in 10,000 H_2O	aq			-119.108				
20,000 H_2O	aq			-119.232				
50,000 H_2O	aq			-119.412				
100,000 H_2O	aq			-119.540				
CH_2ClCH_2OH ethylene chlorohydrin	liq	80.5146		-70.6				
in 200 H_2O	aq			-71.9				
$(CH_3)_2O \cdot HCl$	g	82.5305		-72.8	-48.8		82.6	
$CHCl_2COO^-$	aq	127.9351		-122.4				
$CH_2ClCOCl$ chloroacetylchloride	liq	112.9436		-67.85				
$CHCl_2COOH$ dichloroacetic acid	liq	128.9430		-119.0				44.
ionized	aq			-122.4				
un-ionized	aq			-120.4				
in 200 H_2O	aq			-121.09				
1350 H_2O	aq			-121.59				
in 10 C_6H_6				-118.97				
in 1 CH_3COCH_3				-121.29				
5 CH_3COCH_3				-121.96				
in 1 $(C_2H_5)_2O$				-121.84				
5 $(C_2H_5)_2O$				-123.01				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(43) CARBON

Substance				ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
CCl_3CHO	chloral (trichloroacetaldehyde)	liq	147.3887		-56.45				36.
		g			-47.0				
	unhydrated	aq			-54.4				
	in 500 H_2O	aq			-68.4				
$CHCl_2COCl$	dichloroacetylchloride	liq			-67.27				
CCl_3COOH	trichloroacetic acid	c	163.3881		-120.7				
	ionized	aq			-123.4				
	in 50 H_2O	aq			-121.88				
	100 H_2O	aq			-122.56				
	150 H_2O	aq			-122.83				
	200 H_2O	aq			-122.97				
	500 H_2O	aq			-123.17				
	in 10 C_5H_{12}				-112.95				
	20 C_5H_{12}				-113.20				
	30 C_5H_{12}				-113.35				
	40 C_5H_{12}				-113.45				
	50 C_5H_{12}				-113.53				
	100 C_5H_{12}				-113.9				
	in 10 C_2H_5OH				-120.47				
	20 C_2H_5OH				-120.65				
	30 C_2H_5OH				-120.77				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(44) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CCl_3COOH in 40 C_2H_5OH				-120.88				
50 C_2H_5OH				-120.96				
100 C_2H_5OH				-121.4				
in 5 $(CH_3)_2CO$				-124.25				
10 $(CH_3)_2CO$				-124.37				
20 $(CH_3)_2CO$				-124.52				
30 $(CH_3)_2CO$				-124.61				
40 $(CH_3)_2CO$				-124.67				
50 $(CH_3)_2CO$				-124.7				
in 20 $(C_2H_5)_2O$				-120.51				
50 $(C_2H_5)_2O$				-120.98				
100 $(C_2H_5)_2O$				-121.2				
$CCl_3CH(OH)_2$ chloral hydrate	c	165.4040		-137.7				34.
	g			-107.2				
in 700 H_2O	aq			-136.7				
in 150 $CHCl_3$				-131.2				
$CF_2=CFCl$	g	116.4705	-132.04	-132.7	-125.2	4.096	76.96	20.06
CF_3CF_2Cl	g	154.4673					85.5	
$CF_2=CCl_2$	g	132.9251		-76.3				
CFCl=CFCl cis + trans equil.	g			-78.2				
trans-1,2-difluoro-1,2-dichloroethylene	g					4.308	78.3	20.99

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(45) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CF_2ClCF_2Cl 1,1,2,2-tetrafluoro-1,2-dichloroethane	g	170.9219		-212.8				
CF_3CCl_3	g	187.3765				5.61	88.6	28.8
$CF_2ClCFCl_2$	liq			-188.37				41.5
	g			-181.5				
$CFCl_2CF_2Cl^+$	g			96.5				
CCl_3CF_2Cl	g	203.8311	-115.75	-117.1	-97.3	5.65	91.5	29.5
CCl_3CFCl_2	g	220.2857				6.02	94.3	31.2
$CF_2{=}CHCl$	g	98.4801	-74.25	-75.4	-69.1	3.570	72.39	17.23
CH_3CF_2Cl	liq	100.4960						31.4
	g					3.82	73.4	19.8
CF_3CH_2Cl	g	118.4864				4.21	78.0	21.3
$CHF{=}CCl_2$	g	114.9347				3.769	75.0	18.28
CH_3CFCl_2	g	116.9506				4.12	76.5	21.2
CF_3CHCl_2	g	152.9315				4.81	84.3	24.5
C_2Br_4	g	343.6583				5.374	92.5	24.54
CBr_3CBr_3 hexabromoethane	g	503.4763				7.108	105.6	33.30
$CH{\equiv}CBr$	g	104.9393				2.892	60.6	13.31
$CH_2{=}CHBr$ vinyl bromide	g	106.9552	22.26	18.7	19.3	2.905	65.90	13.27
$CH_2{=}CHBr^+$	g		248.3	246.2				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(46) CARBON

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
C_2H_5Br	ethyl bromide	liq	108.9712		-21.99	-6.64		47.5	24.1
		g		-10.188	-15.42	-6.34	3.259	68.50	15.42
	in 2000 CH_3OH				-21.71				
$CH_3CH_2Br^+$		g		227.1	223.4				
CHBr=CHBr	cis 1,2-dibromoethylene	g	185.8562				3.491	74.38	16.44
	trans 1,2-dibromoethylene	g					3.682	74.90	16.79
CH_3CHBr_2		g	187.8722				3.94	78.3	19.3
CH_2BrCH_2Br	ethylene bromide	liq			-19.4	-5.0		53.37	32.51
		g			-9.16	-2.47		79.1	20.7
	in 2 CCl_4				-19.04				
	10 CCl_4				-18.97				
	in 5 $CHCl_3$				-19.48				
	in 2 CS_2				-18.86				
	10 CS_2				-18.57				
$CHBr_2CHBr_2$		liq	345.6742						39.6
CH_3COBr	acetyl bromide	liq	122.9546		-53.39				
$CH_2BrCOOH$	monobromoacetic acid	c	138.9540						28.48
CBr_3CHO	bromal	liq	280.7567		-31.13				
$CBr_3CH(OH)_2$	bromal hydrate	c	298.7720		-112.				
		aq			-110.				

Table 23(47) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$CF_2=CFBr$	g	160.9265				4.238	80.0	20.51
CF_3CF_2Br	g	198.9233				4.98	85.7	26.1
$CF_2=CBr_2$	g	221.8371				4.537	83.5	21.58
CF_2BrCF_2Br	g	259.8339		-186.5				
$CF_2=CHBr$	g	142.9361				3.682	75.1	17.63
CF_3CH_2Br	g	162.9424				4.299	80.59	21.67
CHF_2CF_2Br	g	180.9329		-197.0				
CH_2ClCH_2Br	liq	143.4162						31.1
$CHClBrCHClBr$	g	256.7622		-8.8				
$CF_2=CBrCl$	g	177.3811				4.385	82.0	21.16
$CF_2BrCHCl_2$	g	213.8421		-107.9				
$CI{\equiv}CI$	g	277.8311				3.901	74.80	16.81
C_2I_4	c	531.6399		73.				
$CH_2=CHI$ vinyl iodide	g	153.9506				3.027	68.1	13.84
C_2H_5I ethyl iodide	liq	155.9666		-9.6	3.5		50.6	27.5
	g		1.95	-1.84	4.57	3.35	73.1	16.0
in 2000 CH_3OH				-8.85				
$C_2H_5I^+$	g		217.1	214.8				
$CHI=CHI$ cis 1,2-diiodoethylene	g	279.8470				3.834	79.81	17.75
trans 1,2-diiodoethylene	g					3.951	80.11	17.64

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(48) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CH_2ICH_2I ethylene iodide	c	281.8630		0.1	13.8		47.	
	g			15.9	18.8		83.2	19.2
CH_3COI acetyl iodide	liq	169.9500		-38.84				
CF_3CF_2I	g	245.9187				5.12	88.8	26.4
CF_3CH_2I	g	209.9378				4.338	82.32	21.78
CH_2BrCH_2I	c	234.8676		-11.3				
C_2H_4S thiacyclopropane	liq	60.1182		12.41	22.52		38.84	
	g		22.562	19.69	23.19	2.732	61.01	12.83
$(CH_3)_2S$ 2-thiapropane (dimethyl sulfide)	liq	62.1341		-15.55	1.45		46.94	28.23
	g		-5.033	-8.90	1.73	3.760	68.32	17.71
$(CH_3)_2S^+$	g		195.2	192.8				
C_2H_5SH ethanethiol	liq			-17.53	-1.28		49.48	28.17
	g		-6.940	-10.95	-1.05	3.617	70.77	17.37
CH_3SSCH_3 2,3-dithiabutane	liq	94.1981		-14.82	1.67		56.26	34.92
	g		-1.730	-5.64	3.64	4.771	80.46	22.54
$CH_3SSCH_3^+$	g		193.4	190.9				
$HSCH_2CH_2SH$ 1,2-ethanedithiol	liq			-12.83				
CH_3COSH thiolacetic acid	liq	76.1176		-52.1				
	g					4.092	74.86	19.33

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(49) CARBON

Substance				ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$C_2H_4SO_3$	ethylene sulfite	liq	108.1164		-119.3				
	in 2800 H_2O	aq			-118.7				
$(CH_3)_2SO$	dimethyl sulfoxide	liq	78.1335		-48.6	-23.7		45.0	35.2
		g		-31.427	-35.96	-19.48	4.132	73.20	21.26
	in 2 H_2O	aq			-50.67				
	10 H_2O	aq			-52.21				
$(CH_3)_2SO_2$	dimethyl sulfone	c	94.1329		-107.8	-72.3		34.	
		g		-83.3	-88.7	-65.2	4.3	74.2	23.9
$C_2H_6SO_3$	dimethyl sulfite	liq	110.1323		-126.7				
	in 2800 H_2O	aq			-126.9				
$C_2H_5HSO_4$	ethyl sulfuric acid	aq	126.1317		-209.3				
$(CHO)_2 \cdot 2H_2SO_3$	glyoxal hydrogen sulfite	aq	222.1933		-374.7				
$N{\equiv}C{-}C{\equiv}N$	cyanogen	g	52.0357	73.386	73.84	71.07	3.028	57.79	13.58
$C_2N_6O_{12}$	hexanitroethane	c	300.0553		28.6				
CH_3NC	methyl isocyanide	liq	41.0529		28.0	38.1		38.	
		g		37.15	35.6	39.6	3.025	58.99	12.65
CH_3CN	acetonitrile	liq			12.8	23.7		35.76	21.86
		g		22.58	20.9	25.0	2.892	58.67	12.48
	in 2 C_2H_5OH				13.116				
	10 C_2H_5OH				12.921				

Table 23(50) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CH_3CN^+	g		304.4	304.2				
C_2H_4NH ethylenimine	liq	43.0688		21.97				
	g			30.2				
$C_2H_5NH_2$ ethylamine	liq	45.0848		-17.7				31.
	g			-11.27				16.7
in 400 H_2O	aq			-24.2				
$(CH_3)_2NH$ dimethylamine	liq			-10.5	16.7		43.58	32.9
	g			-4.41	16.35		65.24	16.9
std. state, m = 1	aq			-16.88	13.85		31.8	
in 400 H_2O	aq			-17.10				
700 H_2O	aq			-17.20				
1000 H_2O	aq			-17.3				
$C_2H_5NH_2^+$	g			194.5				
$(CH_3)_2NH^+$	g			187.1				
$(CH_3)_2NH_2^+$ std. state, m = 1	aq	46.0928		-28.74	-0.80		41.2	
$C_2H_5NH_3^+$ ethylammonium ion	aq			-37.3				
$(CH_3)_2NNH_2$ 1,1-dimethyl hydrazine	liq	60.0995		11.8	49.4		47.32	39.21
	g			20.18	50.31		72.28	
$(CH_3NH)_2$ 1,2-dimethyl hydrazine	liq			13.3	50.8		47.60	40.88
	g			22.70	52.20		74.39	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(51) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$NH_2CH_2CH_2NH_2$ ethylenediamine	liq			-5.82				50.
in 200 H_2O	aq			-13.32				
$NH_2CH_2CH_2NH_2 \cdot H_2O$ ethylenediamine hydrate	liq	78.1148		-76.9				
$NH_2CH_2CH_2NH_3^+$ ethyleneamineammonium ion	aq	61.1074		-25.3				
$NH_3CH_2CH_2NH_3^{++}$ ethylenediammonium ion	aq	62.1154		-36.0				
$C_2H_4N_4$ 3-amino-1,2,4-triazole	c	84.0810		18.4				
$C{=}NH(NH_2)(NHC{\equiv}N)$ cyanoguanidine	c			5.4	42.9		30.90	28.40
cyanoguanidine; in 250 H_2O	aq			11.2				
C_2HN_5 5-cyanotetrazole	c	95.0638		96.1				
$C_2H_5N_5$ 1-methyl-5-aminotetrazole	c	99.0956		46.25				
$C_2H_5N_5$ 2-methyl-5-aminotetrazole	c			50.4				
$C_2H_5N_5$ 5-methylaminotetrazole	c			48.35				
$C_2H_4N_4 \cdot NH_3$ cyanoguanidine ammine	c	101.1116		-12.4				
$C_2H_5N_7$ 5-guanylaminotetrazole	c	127.1090		40.5				
$C_2H_4N_{10}$ 5,5'-hydrazotetrazole	c	168.1212		135.1				
$C_2H_6N_{10} \cdot H_2O$ 1-(5-tetrazolyl)-4-guanyltetrazene hydrate	c	188.1525		45.2				
$H_2NCOCOO^-$ oxamate ion	aq	88.0431		-153.1				
CH_3NCO methyl isocyanate	liq	57.0523		-22.0				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(52) CARBON

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$HOCH_2C{\equiv}N$	glycollic nitrile	liq			-33.7				
	in 200 H_2O	aq			-33.6				
$H_2NCOCOOH$	oxamic acid	c	89.0511		-160.4				
	in 800 H_2O	aq			-153.1				
$CH_3CHNO_2^-$	nitroethane ion	aq	74.0597		-30.3				
$NH_2CH_2COO^-$	std. state, m = 1	aq			-112.280	-75.278		28.54	
CH_3CHNOH	acetaldoxime (high-melting)	c	59.0682		-18.6				
	(low-melting)	liq			-19.5				
		aq			-16.3				
CH_3CONH_2	acetamide	c			-76.0				16.
	in 200 H_2O	aq			-73.9				
	in 32 C_2H_5OH				-73.4				
$C_2H_5NO_2$	nitroethane	liq	75.0676		-33.5				33.
		g			-23.56				
	nitroethane, aci form	aq			-30.7				
	nitroethane, nitro form	aq			-32.				
CH_3CH_2ONO	ethyl nitrite	liq			-30.8				
		g			-24.9				
NH_2CH_2COOH	glycine	c		-121.415	-126.22	-88.09	3.867	24.74	23.71
	ionized; std. state, m = 1	aq			-112.280	-75.278		28.54	
	un-ionized, std. state, m = 1	aq			-122.846	-88.618		37.84	

Table 23(53) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
NH_2CH_2COOH in 20 H_2O	aq			-123.033				
25 H_2O	aq			-123.006				
30 H_2O	aq			-122.985				
40 H_2O	aq			-122.960				
50 H_2O	aq			-122.942				
75 H_2O	aq			-122.913				
100 H_2O	aq			-122.897				
150 H_2O	aq			-122.880				
200 H_2O	aq			-122.871				
300 H_2O	aq			-122.863				
400 H_2O	aq			-122.859				
500 H_2O	aq			-122.856				
700 H_2O	aq			-122.853				
1,000 H_2O	aq			-122.851				
100,000 H_2O	aq			-122.846				
$CH_2OHCONH_2$ glycolamide	c							27.
$HOCH_2CH_2NO_2$ 2-nitroethanol	liq	91.0670		-84.0				
$CH_3CH_2ONO_2$ ethyl nitrate	c		-45.023					
	liq			-45.49	-10.29	9.242	59.08	40.7
	g			-36.82	-8.82		83.23	
$C_2H_5ONO_2^+$	g			223.4				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(54) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$NH_4HC_2O_4$	c	107.0664						36.
std. state, m = 1	aq			-227.3	-185.90		62.8	
$NH_3^+CH_2COOH$ std. state, m = 1	aq	76.0756		-123.784	-91.824		45.46	
CH_3COONH_4 ammonium acetate	c	77.0836		-147.26				
std. state, m = 1	aq			-147.83	-107.26		47.8	17.6
in 2.0 H_2O	aq			-145.662				
2.5 H_2O	aq			-145.720				
3.0 H_2O	aq			-145.770				
3.5 H_2O	aq			-145.822				
4.0 H_2O	aq			-145.880				
4.5 H_2O	aq			-145.946				
5.0 H_2O	aq			-146.020				
5.5 H_2O	aq			-146.090				
6 H_2O	aq			-146.160				
7 H_2O	aq			-146.294				
8 H_2O	aq			-146.405				
9 H_2O	aq			-146.500				
10 H_2O	aq			-146.580				
12 H_2O	aq			-146.685				
15 H_2O	aq			-146.790				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(55) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CH_3COONH_4 in 20 H_2O	aq			-146.935				
25 H_2O	aq			-147.020				
30 H_2O	aq			-147.090				
40 H_2O	aq			-147.186				
50 H_2O	aq			-147.251				
75 H_2O	aq			-147.350				
100 H_2O	aq			-147.407				
150 H_2O	aq			-147.475				
200 H_2O	aq			-147.515				
300 H_2O	aq			-147.558				
400 H_2O	aq			-147.587				
500 H_2O	aq			-147.605				
600 H_2O	aq			-147.618				
700 H_2O	aq			-147.629				
800 H_2O	aq			-147.637				
900 H_2O	aq			-147.645				
1,000 H_2O	aq			-147.650				
1,500 H_2O	aq			-147.671				
2,000 H_2O	aq			-147.683				
3,000 H_2O	aq			-147.696				
4,000 H_2O	aq			-147.705				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(56) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CH_3COONH_4 in 5,000 H_2O	aq			-147.711				
7,000 H_2O	aq			-147.718				
10,000 H_2O	aq			-147.725				
20,000 H_2O	aq			-147.735				
50,000 H_2O	aq			-147.744				
100,000 H_2O	aq			-147.748				
∞ H_2O	aq			-147.83				
$CH_2OHCOONH_4$ ammonium glycolate	c	93.0830		-190.6				
in 200 H_2O	aq			-187.5				
$CH_3NH_3HCO_3$ in 1000 H_2O	aq			-194.4				
$CH(OH)_2COONH_4$ ammonium glyoxylate	aq	109.0824		-228.7				
$(CH_3)_2NH_2OH$ un-ionized; std. state, m = 1	aq	63.1001		-85.19	-42.84		48.5	
$1/n(C_2H_4ON_2)_n$ methylene urea	c	72.0670		-78.1				
$(CONH_2)_2$ oxamide	c	88.0664		-123.0				
$(CH{=}NOH)_2$ glyoxime	c			-21.2				
$HCONHCONH_2$ formylurea	c			-117.8				
in 2000 H_2O	aq			-110.3				
$(CH_2NO_3)_2$ ethylene glycol dinitrate	c	152.0640		-58.9				
$(CH_3)_2NNO$ dimethylnitrosoamine	liq	74.0829		1.1				
$CH_3CH_2NHNO_2$ ethylnitramine	liq	90.0823		-22.4				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(57) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$(CH_3)_2NNO_2$ dimethylnitramine	c			-16.8				
$CH_2(COOH)NH_3NO_3$	c	138.0805		-174.				
$(CH_3)_2NH_2NO_3$ dimethylammonium nitrate	c	108.0977		-83.7				
std. state, m = 1	aq			-78.30	-27.41		76.2	
$C_2H_5NH_3NO_3$ ethylammonium nitrate	liq			-87.7				
	aq			-86.9				
$HOCH_2CH_2NH_3NO_3$ ethanolammonium nitrate	c	124.0971		-138.				
$(NH_4)_2C_2O_4$ ammonium oxalate	c			-268.4				54.
std. state, m = 1	aq			-260.5	-199.0		65.1	
in 2100 H_2O	aq			-261.2				
$(NH_4)_2C_2O_4 \cdot H_2O$	c	142.1124		-340.7				
$CH_3C(NO_2)_3$ trinitroethane	c	165.0627		0.0				
$HOCH_2CH_2N_3$ 2-triazoethanol	liq	87.0816		22.6				
$HO_3CH_2CH_2NH_3NO_3$ nitroxyethylammonium nitrate	c	169.0946		-111.9				
$C_2H_4N_4O$ 5-methoxytetrazole	c	100.0804		16.5				
$C_2H_4N_4O_2$ urazine	c	116.0798		-62.9				
$C_2H_4N_4O_2$ azodicarbamide	c			-69.9				
$C_2H_6N_4O_2$ hydrazodicarbamide	c	118.0957		-119.19				
$(CONHNH_2)_2$ oxalyldihydrazide	c			-70.7				
$(CH_2NH_3NO_3)_2$ ethylenediammonium nitrate	c	186.1252		-156.2				

Table 23(58) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$(CH_2NH_3NO_3)_2$ in 400 H_2O	aq			-135.4				
$C_2H_3N_5O_2$ 3-nitramino-1,2,4-triazole	c	129.0785		26.9				
$C_2H_5N_5O_3$ 1-formamido-2-nitroguanidine	c	147.0938		-35.1				
$C_2H_5N_5O_3$ 3-amino-1,2,4-triazole nitrate	c			-40.9				
$H_2NC(NH)NHCONHNO_2$ nitroguanylurea	c			-74.9				
$H_2NC(NH)NHCONH_3NO_3$ guanylurea nitrate	c	165.1092		-102.1				
$[CH_2N(NH_4)NO_2]_2$ ammonium salt of ethylenedinitramine	c	184.1557		-80.2				
$CHN_4 \cdot N(NO_2)NH_3 \cdot C(NH)NH_2$ guanidine salt of 5-nitroaminotetrazole	c	189.1372		26.6				
CF_3CN	g	95.0242				3.781	71.22	18.61
$CHF_2CH_2NH_2$ 2,2-difluoroethylamine	liq	81.0656		-119.0				
CH_2FCONH_2 fluoroacetamide	c	77.0587		-118.7				
CHF_2CONH_2 difluoroacetamide	c	95.0491		-167.3				
$CHF_2CH_2NHNO_2$ 2,2-difluoroethylnitramine	c	126.0632		-120.0				
CCl_3CN	g	144.3880				4.707	80.42	22.96
CH_2ClCN	g	75.4979				3.232	68.37	14.69
$(CH_3)_2NH_2Cl$ std. state, m = 1	aq	81.5458		-68.69	-32.17		54.7	
in 50 H_2O	aq			-68.567				
100 H_2O	aq			-68.581				
150 H_2O	aq			-68.586				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(59) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$(CH_3)_2NH_2Cl$ in 200 H_2O	aq			-68.590				
300 H_2O	aq			-68.596				
400 H_2O	aq			-68.6				
500 H_2O	aq			-68.604				
600 H_2O	aq			-68.607				
700 H_2O	aq			-68.611				
800 H_2O	aq			-68.613				
900 H_2O	aq			-68.616				
1,000 H_2O	aq			-68.618				
1,500 H_2O	aq			-68.627				
2,000 H_2O	aq			-68.632				
3,000 H_2O	aq			-68.640				
4,000 H_2O	aq			-68.645				
5,000 H_2O	aq			-68.649				
7,000 H_2O	aq			-68.654				
10,000 H_2O	aq			-68.658				
20,000 H_2O	aq			-68.665				
50,000 H_2O	aq			-68.674				
100,000 H_2O	aq			-68.678				
∞ H_2O	aq			-68.69				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(60) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$C_2H_5NH_3Cl$ ethylammonium chloride; in 400 H_2O	aq			-77.4				
$NH_2CH_2CH_2NH_3Cl$ in 5000 H_2O	aq	96.5604		-65.3				
$(CH_2NH_3Cl)_2$ ethylenediammonium chloride	c	133.0214		-122.7				
in 5000 H_2O	aq			-115.92				
$CH_2ClCONH_2$ chloroacetamide	c	93.5133		-81.1				
in 2500 H_2O	aq			-75.3				
$CH_2(COOH)NH_3Cl$ std. state, m = 1	aq	111.5286		-163.736	-123.196		59.0	
in 200 H_2O	aq			-163.6				
$CH_2ClCOONH_4$	c			-153.7				
in 200 H_2O	aq			-151.1				
$CHCl_2CONH_2$ in 5000 H_2O	aq	127.9583		-76.8				
CCl_3CONH_2 trichloroacetamide	c	162.4033		-85.8				
in 2000 H_2O	aq			-77.2				
CCl_3COONH_4	c	180.4187		-156.7				
in 200 H_2O	aq			-155.6				
$CCl_3COONH_4 \cdot 2H_2O$	c	216.4494		-306.0				
CCl_3COONH_3OH in 300 H_2O	aq	196.4181		-155.9				
CF_2ClCN	g	111.4788				3.994	76.10	19.60
$CFCl_2CN$	g	127.9334				4.347	79.37	21.27

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(61) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$I(CN)_2^-$ std. state, m = 1	aq	178.9401			85.61			
$(SCN)_2$ thiocyanogen	liq	116.1637		74.3				
CH_3NCS methyl isothiocyanate	c	73.1169		19.0				
	g		33.46	31.3	34.5	3.464	69.29	15.65
CH_3SCN methyl thiocyanate	liq			28.4				
	g			38.3				
CH_3NCS^+ methyl isothiocyanate	g		246.8	246.1				
CH_3SCN^+ methyl thiocyanate	g			271.8				
$NH_2CH_2CH_2SO_3^-$ std. state, m = 1	aq	124.1390		-171.92	-121.76		47.8	
$NH_2CH_2CH_2SO_3H$ taurine	c	125.1470		-187.7	-134.3		36.8	33.6
ionized; std. state, m = 1	aq			-171.92	-121.76		47.8	
un-ionized; std. state, m = 1	aq			-181.92	-134.12		55.7	
in 50 H_2O	aq			-182.09				
100 H_2O	aq			-182.03				
150 H_2O	aq			-182.00				
∞ H_2O	aq			-181.92				
$(CHO)_2 \cdot 2NH_4HSO_3$ in 800 H_2O	aq	256.2545		-465.6				
$(CHO)_2 \cdot 2NH_4HSO_3 \cdot H_2O$ glyoxal ammonium bisulfite	c	274.2699		-544.1				
$[(CH_3)(NO_2)N]_2SO_2$ N,N-dinitro-N,N-dimethylsulfamide	c	214.1573		-65.7				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(62) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$[C{=}NH(NH_2)(NH_3)]_2SO_4$ guanidine sulfate	c	216.2197		-288.0				
	aq			-281.2				
CH_3COOCH_3	liq	74.0801		-106.42				
$(CH_3)_3N$ trimethylamine	liq	59.1119		-11.0	24.1		49.82	32.31
	g			-5.81	23.65		68.6	
std. state, m = 1	aq			-18.17	22.22		31.9	
in 400 H_2O	aq			-18.40				
700 H_2O	aq			-18.50				
1000 H_2O	aq			-18.6				
$(CH_3)_3NH^+$ std. state, m = 1	aq	60.1198		-26.99	8.90		47.0	
$(CH_3)_2NH_2HCO_3$ in 1000 H_2O	aq	107.1101		-193.3				
$(CH_3)_3NHOH$ un-ionized; std. state, m = 1	aq	77.1272		-86.48	-34.47		48.6	
$(CH_3)_3NHNO_3$ trimethylammonium nitrate	c	122.1248		-82.2				
std. state, m = 1	aq			-76.55	-17.71		82.0	
$(CH_3NH_3)_2CO_3$ in 2000 H_2O	aq	124.1407		-218.6				
$[C{=}NH(NH_2)(NH_3)]_2CO_3$ guanidine carbonate	c	180.1675		-232.10	-133.23		70.6	61.87
$(CH_3)_3NHCl$ trimethylammonium chloride	c	95.5728		-67.29				
std. state, m = 1	aq			-66.94	-22.47		60.5	
in 50 H_2O	aq			-67.020				
100 H_2O	aq			-66.962				
150 H_2O	aq			-66.936				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(63) CARBON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$(CH_3)_3NHCl$ in 200 H_2O	aq			-66.920				
300 H_2O	aq			-66.907				
400 H_2O	aq			-66.9				
500 H_2O	aq			-66.897				
700 H_2O	aq			-66.894				
1,000 H_2O	aq			-66.893				
2,000 H_2O	aq			-66.894				
3,000 H_2O	aq			-66.899				
4,000 H_2O	aq			-66.902				
5,000 H_2O	aq			-66.904				
7,000 H_2O	aq			-66.908				
10,000 H_2O	aq			-66.912				
20,000 H_2O	aq			-66.917				
50,000 H_2O	aq			-66.925				
100,000 H_2O	aq			-66.928				
∞ H_2O	aq			-66.94				
$(C_2H_5)_2O$ diethyl ether	liq	74.1237		-66.82				
	g			-60.26				
in 2 C_2HCl_5				-68.30				
10 C_2HCl_5				-68.69				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(64) CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$(C_2H_5)_2O$ in 2 $CHCl_2COOH$				-70.14				
10 $CHCl_2COOH$				-70.21				
$(C_2H_5)_2S$ diethyl sulfide	liq	90.1883		-28.43	2.81		64.36	40.97
	g		-13.15	-19.86	4.34	5.467	87.96	27.97
$(C_2H_5)_2NH$ diethylamine	liq	73.1390		-24.7				
	g			-17.07				
in 30 H_2O	aq			-31.9				
200 H_2O	aq			-32.1				
$(C_2H_5)_2NH_2^+$	aq	74.1469		-45.1				
$C_2H_5NH_3OOCCH_3$ in 500 H_2O	aq	105.1378		-153.4				
$(CH_3)_3NHHCO_3$ in 1000 H_2O	aq	121.1372		-191.8				
$CH_2OHCOONH_4 \cdot CH_2OHCOOH$ ammonium acid glycolate	c	169.1354		-353.1				
$(C_2H_5)_2NH_2NO_3$ diethylammonium nitrate	c	136.1518		-100.1				
	aq			-94.7				
$[CO(NH_2)(NH_3)]_2C_2O_4$ urea oxalate	c	210.1475		-365.3				
in 500 H_2O	aq			-348.1				
$(C_2H_5)_2NH_2Cl$	c	109.5999		-85.6				
in 200 H_2O	aq			-84.95				
$CH_2ClCOONH_4 \cdot CH_2ClCOOH \cdot H_2O$ ammonium acid monochloroacetate	c	224.0420		-347.4				

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 23(65) — CARBON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$CCl_3COONH_4 \cdot CCl_3COOH \cdot H_2O$ ammonium acid trichloroacetate	c	361.8221		-349.2				
$(C_2H_5NH_3)_2SO_4$ in 1000 H_2O	aq	188.2471		-291.6				
$(CH_3)_3NHOOCCH_3$ in 400 H_2O	aq	119.1649		-142.9				
$[(CH_3)_2NH_2]_2CO_3$ in 2000 H_2O	aq	152.1949		-216.6				
$(C_2H_5)_3N$ triethylamine	liq	101.1932		-32.1				
	g			-22.9				
	aq			-41.6				
$(C_2H_5)_3NH^+$	aq	102.2011		-51.8				
$(C_2H_5)_3NHNO_3$ triethylammonium nitrate	c	164.2060		-107.0				
	aq			-101.4				
$(C_2H_5)_3NHCl$ triethylammonium chloride	c	137.6541		-92.2				
in 25 H_2O	aq			-91.68				
$[(CH_3)_3NH]_2SO_4$ in 800 H_2O	aq	216.3013		-270.9				
$[(CH_3)_3NH]_2CO_3$ in 2000 H_2O	aq	180.2490		-212.2				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 24(1) SILICON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Si	c	28.086	0	0	0	0.769	4.50	4.78
	amorp			1.0				
	g		107.86	108.9	98.3	1.805	40.12	5.318
Si^{+}	g		295.83	298.35				
Si^{2+}	g		672.71	676.71				
Si^{3+}	g		1444.50	1449.98				
Si^{4+}	g		2485.50	2492.46				
Si^{5+}	g		6331.3	6339.8				
Si^{6+}	g		11062.6	11072.6				
Si^{7+}	g		16747.	16758.				
Si^{8+}	g		23756.	23769.				
Si^{9+}	g		31871.	31886.				
Si^{10+}	g		41127.	41143.				
Si^{11+}	g		52108.	52125.				
Si^{12+}	g		64178.	64196.				
Si_2	g	56.172	141.32	142.	128.	2.22	54.92	8.22
Si_3	g	84.258	146.4	147.		2.9		12.9
SiO	g	44.0854	-24.08	-23.8	-30.2	2.082	50.55	7.15
SiO_2 α, quartz	c	60.0848		-217.72	-204.75	1.657	10.00	10.62
α, cristobalite	c			-217.37	-204.56	1.671	10.20	10.56

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 24(2) — SILICON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
SiO_2 α, tridymite	c			-217.27	-204.42	1.693	10.4	10.66
	amorp			-215.94	-203.33		11.2	10.6
	g			-77.				
	aq			-214.4				
SiH	g	29.0940	86.	86.28		2.069		
SiH_4	g	32.1179	10.30	8.2	13.6	2.517	48.88	10.24
Si_2H_6	g	62.2198	23.04	19.2	30.4	3.768	65.14	19.31
Si_3H_8	liq	92.3218		22.1				
	g			28.9				
H_2SiO_3	c	78.1001		-284.1	-261.1		32.	
undissoc.; std. state, m = 1	aq			-282.7	-258.0		26.	
H_4SiO_4	c	96.1155		-354.0	-318.6		46.	
undissoc.; std. state, m = 1	aq			-351.0	-314.7		43.	
$HSi(OH)_6^-$ undissoc.; std. state, m = 1	aq	131.1382			-414.6			
$H_2[Si(OH)_6]$ undissoc.; std. state, m = 1	aq	132.1462		-487.6	-428.1		77.	
$H_2Si_2O_5$	c	138.1849		-499.2	-464.5		46.	
$H_6Si_2O_7$	c	174.2156		-638.0	-579.8		79.	
SiF	g	47.0844	1.	1.7	-5.8	2.260	53.94	7.80
SiF_2	g	66.0828	-147.75	-148.	-150.	2.630	60.38	10.49

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 24(3) SILICON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
SiF_4	g	104.0796	-384.66	-385.98	-375.88	3.663	67.49	17.60
std. state, m = 1	aq				-384.2			
SiF_6^{2-} std. state, m = 1	aq	142.0764		-571.0	-525.7		29.2	
SiH_3F	g	50.1083				2.617	56.95	11.33
$SiHF_3$	g	86.0892				2.867	64.96	14.47
H_2SiF_6	aq	144.0923						
in 41 HF + 175 H_2O	aq			-568.0				
160 HF + 720 H_2O	aq			-573.2				
363 HF + 1785 H_2O	aq			-568.7				
762 HF + 3385 H_2O	aq			-567.8				
SiCl	g	63.539	45.	45.39		2.267		8.81
$SiCl_2$	g	98.992	-39.61	-39.59	-42.35	2.98	67.0	12.16
$SiCl_4$	liq	169.898		-164.2	-148.16		57.3	34.73
	g		-156.508	-157.03	-147.47	4.633	79.02	21.57
SiH_3Cl	g	66.5629				2.733	59.88	12.20
SiH_2Cl_2	g	101.0079				3.144	68.26	14.45
$SiCl_3H$	liq	135.4530		-128.9	-115.34		54.4	
	g		-121.40	-122.6	-115.2	3.872	74.99	18.12

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Table 24(4) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — SILICON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
SiBr	g	107.995	51.30	50.		2.40		9.23
$SiBr_4$	liq	347.722		-109.3	-106.1		66.4	
	g			-99.3	-103.2	5.317	90.29	23.21
SiH_3Br	g	111.0189				2.812	62.69	12.63
SiH_2Br_2	g	189.9199				3.411	74.0	15.66
$SiHBr_3$	liq	268.8210		-85.0	-80.4		59.3	
	g			-75.9	-78.5	4.282	83.28	19.30
$SiCl_3Br$	g	214.354				4.662	83.64	21.72
$SiCl_2Br_2$	g	258.810				4.955	88.2	22.40
$SiClBr_3$	g	303.266				5.121	90.1	22.79
SiI_4	c	535.7036		-45.3				
SiH_3I	g	158.0143				2.886	64.73	13.00
SiS	g	60.150	26.6	26.88	14.56	2.135	53.43	7.71
SiS_2	c	92.214		-49.5				
SiSe	g	107.046	23.	23.78		2.18		8.04
$SiSe_2$	c	186.006		-7.				
SiTe	g	155.686	31.	30.99		2.22		8.31
SiN	g	42.0927	116.	116.28	109.01	2.087	51.78	7.21

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 24(5) SILICON

Substance				ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
Si_3N_4	α	c	140.2848		-177.7	-153.6		24.2	
$NH_4HSi(OH)_6$	std. state, m = 1	aq	149.1768			-433.6			
$SiF_4 \cdot 2NH_3$		c	138.1408		-463.				
$(NH_4)_2SiF_6$	hexagonal	c	178.1536	-633.79	-640.94	-565.38	10.116	66.98	54.52
	cubic	c		-633.908	-640.67	-565.40	10.498	67.99	59.25
	ionized; std. state, m = 1	aq			-634.3	-563.6		83.4	
	in 555 H_2O	aq			-633.605				
	795 H_2O	aq			-633.465				
	1,500 H_2O	aq			-633.200				
	2,775 H_2O	aq			-632.714				
SiC	β, cubic	c	40.0972	-15.36	-15.6	-15.0	0.781	3.97	6.42
	α, hexagonal	c			-15.0	-14.4		3.94	6.38
		g		175.6	177.		2.4		
SiC_2		g	52.1083	145.7	147.		2.5		
Si_2C		g	68.1832	131.1	132.		2.7		
Si_2C_2		g	80.1943	167.					
Si_2C_3		g	92.2054	176.					
Si_3C		g	96.2692	161.					

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 24(6) SILICON

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$SiH_3(CH_3)$	methylsilane	g	46.1450				3.266	61.28	15.74
SiH_3CCH	silylacetylene	g	56.1402				3.511	64.35	17.34
SiH_3CHCH_2	vinylsilane	g	58.1561		-2.				
$SiH_2(CH_3)_2$	dimethylsilane	g	60.1721				4.293	71.59	22.00
$SiH_3C_2H_5$	ethylsilane	g	60.1721	-29.					
$SiH(CH_3)_3$	trimethylsilane	g	74.1992				5.324	79.09	28.18
$Si(CH_3)_4$	tetramethylsilane	liq	88.2262		-63.	-24.		66.27	48.78
		g			-57.149	-23.934	6.539	85.78	34.39
$SiH(C_2H_5)_3$	triethylsilane	liq	116.2804		-54.				
$Si(C_2H_5)_4$	tetraethylsilane	liq	144.3346		-68.				
$SiH(OCH_3)_3$	trimethoxysilane	liq	122.1974		-199.				
$Si(OCH_3)_4$	tetramethoxysilane	liq	152.2238		-302.				
$SiH(OC_2H_5)_3$	triethoxysilane	liq	164.2786		-226.				
$Si(OC_2H_5)_4$	tetraethoxysilane	liq	208.3322		-334.				
$[(CH_3)_3Si]_2O$	hexamethyldisiloxane	liq	162.3818	-188.65	-194.8	-129.5	16.170	103.69	74.42
		g		-174.07	-185.88	-127.81	10.51	127.85	57.00
$SiF_4 \cdot N(CH_3)_3$		c	163.1915		-419.3				
$SiF_4 \cdot 2N(CH_3)_3$		c	222.3034		-439.5				
$(CH_3)_3SiCl$	trimethylchlorosilane	liq	108.6442		-91.5	-58.93		66.5	
		g			-84.32	-58.23		88.2	
$Si(OC_2H_5)_3Cl$	triethoxychlorosilane	liq	198.7236		-294.5				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 25(1) GERMANIUM

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
Ge		c	72.59	0	0	0	1.105	7.43	5.580
		g		89.34	90.0	80.3	1.768	40.103	7.345
Ge^{+}		g		271.18	273.32				
Ge^{2+}		g		638.63	642.25				
Ge^{3+}		g		1427.85	1432.95				
Ge^{4+}		g		2482.0	2488.6				
Ge^{5+}		g		4637.	4645.				
Ge_2		g	145.18	113.	113.08	99.5	2.29	60.4	8.5
Ge_3		g	217.77	113.	112.95	99.3	3.27	68.1	13.8
Ge_4		g	290.36	114.	113.98	99.4	4.40	78.8	19.2
GeO	brown	c	88.589		-50.7	-56.7		12.	
	yellow	c				-49.5			
		g		-11.	-11.04	-17.49	2.102	53.58	7.39
GeO_2	hexagonal	c	104.589		-131.7	-118.8		13.21	12.45
		amorp			-128.4				
Ge_2O_2		g	177.179		-112.				
Ge_3O_3		g	265.768		-212.				
GeH_4		g	76.622	19.11	21.7	27.1	2.567	51.87	10.76
GeH_4^{+}		g		261.	265.1				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 25(2) GERMANIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Ge_2H_6	liq	151.228		32.82				
	g			38.8				
$Ge_2H_6^+$	g			329.				
Ge_3H_8	liq	225.834		46.3				
	g			54.2				
$Ge_3H_8^+$	g			277.				
H_2GeO_3	aq	122.604		-195.73				
GeF	g	91.588	-8.	-7.97		2.185		8.30
GeF_2	g	110.587	-121.					
GeF_4	g	148.584				4.163	72.36	19.56
GeH_3F	g	94.612				2.731	60.39	12.34
H_2GeF_6	aq	188.596		-481.7				
GeCl	g	108.043	37.09	37.	30.	2.290	58.8	8.81
$GeCl_4$	liq	214.402		-127.1	-110.6		58.7	
	g		-118.06	-118.5	-109.3	5.050	83.08	22.97
GeH_3Cl	g	111.067				2.865	63.00	13.08
$GeHCl_3$	liq	179.957					53.6	
	g					4.192	79.06	19.40

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 25(3) GERMANIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
GeBr	g	152.499	58.	56.32		2.355		8.87
$GeBr_2$	g	232.408		-15.0	-25.5		79.1	
$GeBr_4$	liq	392.226		-83.1	-79.2		67.1	
	g		-64.61	-71.7	-76.0	5.736	94.66	24.34
GeH_3Br	g	155.523				2.966	65.66	13.47
GeI_2	c	326.399		-21.	-20.		32.	
	g			11.2	-1.0		76.	
GeI_4	c	580.208		-33.9	-34.5		64.8	
	g		-12.31	-13.6	-25.4	6.12	102.49	24.89
in $HCl \cdot 14.3H_2O$	aq			-35.65				
$GeIH_3$	g	202.518				3.037	67.65	13.75
GeS	c	104.654		-16.5	-17.1		17.	
	g		22.0	22.	10.	2.185	56.	8.05
GeS_2	c	136.718		-45.3				
GeSe	c	151.55		-22.0				
	g		23.	22.84		2.26		8.42
GeTe	c	200.19		-6.				
	g		42.25	42.		2.32		8.59
$GeTe_2$	g	327.79		44.				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 25(4) GERMANIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Ge_3N_4	c	273.797		-15.1				
GeP	c	103.564		-5.	-4.		15.	
GeC	g	84.601	150.	151.				
GeC^+	g		388.	390.				
GeC_2	g	96.612	142.	143.				
Ge_2C	g	157.191	130.	131.				
Ge_3C	g	229.781	136.	137.				
$Ge(C_2H_5)_4$	liq	188.839		-49.5				
GeSi	g	100.676	126.	127.				
Ge_2Si	g	173.266	123.	124.				
Ge_3Si	g	245.856	121.	122.				
GeSiC	g	112.687	127.	128.				
Ge_2SiC	g	185.277	138.	139.				

Table 26(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

TIN

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
Sn	I, white	c	118.69	0	0	0	1.505	12.32	6.45
	II, gray	c		-0.371	-0.50	0.03	1.376	10.55	6.16
		g		72.18	72.2	63.9	1.485	40.243	5.081
Sn^+		g		241.54	243.04				
Sn^{2+}		g		578.97	581.95				
	in aq HCl	aq			-2.1	-6.5		-4.	
Sn^{3+}		g		1282.9	1287.4				
Sn^{4+}		g		2222.3	2228.3				
	in aq HCl	aq			7.3	0.6		-28.	
Sn^{5+}		g		3889.	3896.				
SnO		c	134.689		-68.3	-61.4		13.5	10.59
		g					2.117	55.45	7.55
SnO_2		c	150.689		-138.8	-124.2		12.5	12.57
SnH_4		g	122.722	41.78	38.9	45.0	2.669	54.39	11.70
SnH_4^+		g		254.	252.6				
$SnOH^+$	std. state, m = 1	aq	135.697		-68.4	-60.9		12.	
$SnO(OH)^+$	std. state, m = 1	aq	151.697			-113.3			
$Sn(OH)_2$	precipitated	c	152.705		-134.1	-117.5		37.	
$Sn(OH)_4$	precipitated	c	186.719		-265.3				
SnF^+	std. state, m = 1	aq	137.688			-80.1			

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Table 26(2) — TIN

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
SnO(OH)F	std. state, m = 1	aq	188.686			-188.5			
$SnCl^+$	undissoc., in aq HCl;								
	std. state, m = 1	aq	154.143		-39.4	-39.4		23.	
$SnCl_2$		c	189.596		-77.7				
	in aq HCl	aq			-79.3				
	un-ionized, in aq HCl;								
	std. state, m = 1	aq			-78.8	-71.6		41.	
$SnCl_2 \cdot 2H_2O$		c	225.627		-220.2				
$SnCl_3^-$	in aq HCl; std. state, m = 1	aq	225.049		-116.4	-102.8		62.	
$SnCl_4$		liq	260.502		-122.2	-105.2		61.8	39.5
		g		-112.16	-112.7	-103.3	5.355	87.4	23.5
	in aq HCl; std. state, m = 1	aq			-152.5	-124.9		26.	
	$CHOOC_2H_5$				-139.7				
	$CH_3COOC_2H_5$				-139.6				
	$C_3H_7COOC_2H_5$				-138.4				
	$C_6H_5COOC_2H_5$				-130.6				
$SnCl_6^{2-}$		aq	331.408		-231.9				
SnOHCl	std. state, m = 1	aq	171.150		-108.4	-93.7		30.	
$SnOHCl \cdot H_2O$		c	189.166			-155.0			

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 26(3) TIN

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$SnBr^+$ in aq HBr; std. state, m = 1	aq	198.599		-29.8	-32.4		23.	
$SnBr_2$	c	278.508		-58.2				
	aq			-56.8				
in aq HBr; std. state, m = 1	aq			-58.8	-57.8		45.	
$SnBr_3^-$ in aq HBr; std. state, m = 1	aq	358.417		-89.6	-82.9		60.	
$SnBr_4$	c	438.326		-90.2	-83.7		63.2	
	g			-75.2	-79.2	5.982	98.43	24.71
in $HCOOC_2H_5$				-100.5				
$CH_3COOC_2H_5$				-93.7				
$HCOOC_4H_9$				-100.0				
$C_3H_7COOC_2H_5$				-92.3				
$CH_3COOC_4H_9$				-93.6				
$SnBr_4 \cdot 8H_2O$	c	582.449		-661.5				
	liq			-651.3				
SnOHBr std. state, m = 1	aq	215.606		-97.4	-86.7		35.	
$SnCl_3Br$	g	304.958				5.508	92.8	23.9
$SnClBr_3$	g	393.870				5.770	97.6	24.4
SnI_2	c	372.499		-34.3				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 26(4) TIN

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
SnI_2 in aq HCl	aq			-28.5				
SnI_4	c	626.308						20.3
	g					6.360	106.6	25.2
SnS	c	150.754		-24.	-23.5		18.4	11.77
	g			28.5				
SnS_2	c	182.818					20.9	16.76
$SnSO_4^{2+}$ std. state, m = 1	aq	214.752			-173.1			
$Sn(SO_4)_2$	c	310.813		-389.4				
std. state, m = 1	aq				-354.2			
SnSe	c	197.65		-21.7				
	g			30.8				
SnTe	c	246.29		-14.6				
	g			38.4				
NH_4SnCl_3 std. state, m = 1	aq	243.088		-148.1	-121.8		89.	
$(NH_4)_2SnCl_6$	c	367.485		-295.6				
	aq			-293.9				
$SnCl_2 \cdot 2.5NH_3$	c	232.172		-144.0				
$SnCl_2 \cdot 4NH_3$	c	257.718		-175.7				
$SnCl_2 \cdot 9NH_3$	c	342.871		-273.0				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 26(5) TIN

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$SnBr_2 \cdot NH_3$	c	295.539		-87.				
NH_4SnBr_3 std. state, m = 1	aq	376.456		-121.3	-101.9		87.	
$SnBr_2 \cdot 2NH_3$	c	312.569		-112.9				
$(NH_4)_2SnBr_6$	c	314.585					120.2	63.97
$SnBr_2 \cdot 3NH_3$	c	329.600		-137.2				
$SnBr_2 \cdot 5NH_3$	c	363.661		-180.2				
$SnBr_2 \cdot 9NH_3$	c	431.783		-254.1				
$SnI_2 \cdot NH_3$	c	389.529		-61.				
$SnI_2 \cdot 2NH_3$	c	406.560		-85.3				
$SnI_2 \cdot 3NH_3$	c	423.591		-109.1				
$SnI_2 \cdot 5NH_3$	c	457.652		-153.3				
$SnI_2 \cdot 9NH_3$	c	525.774		-230.5				
$SnCl_4 \cdot 1.5PH_3$	c	311.498		-147.8				
$Sn(CH_3)_2H_2$	liq	150.776		14.5				
	g			21.				
$Sn(CH_3)_3H$	liq	164.803		-2.1				
	g			5.				
$Sn(CH_3)_4$	liq	178.830		-12.5				
	g			-4.5				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 26(6) TIN

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Sn(C_2H_5)_2H_2$	liq	178.830		2.1				
	g			11.0				
$Sn(CH_3)_3C_2H_5$	liq	192.857		-16.0				
	g			-7.				
$Sn(CHCH_2)_4$	liq	226.875		72.				
$Sn(C_2H_5)_4$	liq	234.939		-22.9				
	g			-10.9				
$Sn_2(CH_3)_6$	liq	327.590		-21.6				
in C_6H_{12}; cyclohexane				-21.1				
$Sn(CH_3)_2Cl_2$	c	219.666		-80.4				
$Sn(CH_3)_3Br$	liq	243.704		-45.2				
$Sn(CH_3)_3I$	liq	290.700		-32.4				
in CCl_4				-31.2				

Table 27(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

LEAD

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
Pb		c	207.19	0	0	0	1.644	15.49	6.32
		g		46.76	46.6	38.7	1.481	41.889	4.968
	in Hg; saturated				0.007	-0.270		16.42	
Pb^+		g		217.795	219.116				
Pb^{2+}		g		564.44	567.25				
	std. state, m = 1	aq			-0.4	-5.83		2.5	
Pb^{3+}		g		1300.93	1305.22				
Pb^{4+}		g		2276.9	2282.7				
Pb^{5+}		g		3864.	3871.				
PbO	yellow	c	223.189	-51.766	-51.94	-44.91	2.507	16.42	10.94
	red	c			-52.34	-45.16		15.9	10.95
$PbO \cdot 1/3H_2O$		c	282.640			-63.7			
PbO_2		c	239.189		-66.3	-51.95		16.4	15.45
Pb_2O_3		c	462.378					36.3	25.74
Pb_3O_4		c	685.568		-171.7	-143.7		50.5	35.1
$PbOH^+$	undissoc.; std. state, m = 1	aq	224.197			-54.1			
$HPbO_2^-$	std. state, m = 1	aq	240.197			-80.90			
$Pb(OH)_2$		c	241.205			-108.1			
	precipitated	c			-123.3				

Table 27(2) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

LEAD

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
H_2PbO_2	undissoc.; std. state, m = 1	aq				-95.8			
$Pb(OH)_3^-$	std. state, m = 1	aq	258.212			-137.6			
$Pb_3(OH)_4^{2+}$	std. state, m = 1	aq	689.599		-248.0	-212.4		56.	
$Pb_4(OH)_4^{4+}$	std. state, m = 1	aq	896.769		-254.8	-223.8		56.	
$Pb_6(OH)_8^{4+}$	std. state, m = 1	aq	1379.179		-499.5	-430.3		119.	
PbF^+	std. state, m = 1	aq	226.188			74.18			
PbF_2		c	245.187		-158.7	-147.5		26.4	
	std. state, m = 1	aq			-159.4	-139.11		-4.1	
	undissoc.; std. state, m = 1	aq				-142.6			
PbF_4		c	283.184		-225.1				
$PbCl^+$	std. state, m = 1	aq	242.643			-39.39			
$PbCl_2$		c	278.096		-85.90	-75.08		32.5	
	ionized; std. state, m = 1	aq			-80.3	-68.57		29.5	
	undissoc.; std. state, m = 1	aq				-71.03			
$PbCl_3^-$	std. state, m = 1	aq	313.549			-101.9			
$PbCl_4$		liq	349.002		-78.7				
	in CCl_4				-77.99				
$PbClO_3^+$	std. state, m = 1	aq	290.641			-6.2			
$Pb(ClO_3)_2$	undissoc.; std. state, m = 1	aq	374.092			-6.6			

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 27(3) LEAD

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$PbO \cdot PbCl_2$	c	501.285		-144.7				
$2PbO \cdot PbCl_2$	c	724.475		-199.8				
$3PbO \cdot PbCl_2$	c	947.664		-253.4				
PbClOH	c	259.650			-114.8			
$3Pb(OH)_2 \cdot PbCl_2$	c	1001.710			-505.1			
PbFCl	c	261.641		-127.8	-116.7		29.1	
$PbBr^+$ std. state, m = 1	aq	287.099			-32.2			
$PbBr_2$	c	367.008		-66.6	-62.60		38.6	19.15
ionized; std. state, m = 1	aq			-58.5	-55.53		41.9	
undissoc.; std. state, m = 1	aq				-57.5			
$PbBr_3^-$ std. state, m = 1	aq	446.917			-82.0			
$PbBrO_3^+$ std. state, m = 1	aq	335.097			-7.9			
$Pb(BrO_3)_2$	c	463.004			-11.95			
std. state, m = 1	aq			-40.4	-5.0		80.5	
$PbO \cdot PbBr_2$	c	590.197		-122.9				
$2PbO \cdot PbBr_2$	c	813.387		-177.3				
$3PbO \cdot PbBr_2$	c	1036.576		-231.9				
PbBrF	c	306.097			-108.9			

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 27(4) LEAD

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
PbI^+ std. state, m = 1	aq	334.094			-20.8			
PbI_2	c	460.999	-41.81	-41.94	-41.50	4.666	41.79	18.49
ionized; std. state, m = 1	aq			-26.8	-30.49		55.7	
undissoc.; std. state, m = 1	aq				-34.3			
PbI_3^- std. state, m = 1	aq	587.903			-47.5			
PbI_4^{2-} std. state, m = 1	aq	714.808			-60.9			
$Pb(IO_3)_2$	c	556.995		-118.4	-84.0		74.8	
$PbI_2 \cdot HI \cdot 5H_2O$	c	678.988		-400.6				
PbS	c	239.254		-24.0	-23.6		21.8	11.83
$PbSO_3$	c	287.252		-160.1				
$PbSO_4$	c	303.252	-217.82	-219.87	-194.36	4.795	35.51	24.667
PbS_2O_3	c	319.316		-161.1				
PbS_2O_6	aq	367.314		-286.8				
$PbS_2O_6 \cdot 4H_2O$	c	439.376		-568.6				
PbS_3O_6	c	399.378		-290.7				
$PbSO_4 \cdot PbO$	c	526.441		-280.0	-246.7		49.4	
$PbSO_4 \cdot 2PbO$	c	749.630		-334.4	-294.0		65.6	
$PbSO_4 \cdot 3PbO$	c	972.820		-388.8	-341.2		81.4	
PbSe	c	286.15		-24.6	-24.3		24.5	12.0

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 27(5) LEAD

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$PbSeO_3$		c	334.148		-128.5				
$PbSeO_4$		c	350.148		-145.6	-120.7		40.1	
PbTe		c	334.79		-16.9	-16.6		26.3	12.08
$PbTeO_4$		c	398.788		-180.				
$Pb(N_3)_2$	monoclinic	c	291.230		114.3	149.3		35.4	
	orthorhombic	c			113.8	148.7		35.7	
$PbNO_3^+$	std. state, m = 1	aq	269.195			-33.9			
$Pb(NO_3)_2$		c	331.200		-108.0				
	ionized; std. state, m = 1	aq			-99.5	-59.05		72.5	
	in 40 H_2O				-102.9				
	in 100 H_2O				-101.8				
	in 200 H_2O				-101.2				
	in 400 H_2O				-100.7				
	in 10,000 H_2O				-100.0				
$Pb(N_3)_2 \cdot PbO$		c	514.420			79.6			
$Pb(NO_3)_2 \cdot NH_3$			348.230		-132.5				
$Pb(NO_3)_2 \cdot 3NH_3$		c	382.292		-178.1				
$Pb(NO_3)_2 \cdot 6NH_3$		c	433.383		-233.7				
$PbCl_2 \cdot NH_3$		c	295.127		-110.4				

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 27(6) — LEAD

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$PbCl_2 \cdot 3/2NH_3$	c	303.642		-121.6				
$PbCl_2 \cdot 2NH_3$	c	312.157		-132.6				
$PbCl_2 \cdot 13/4NH_3$	c	333.445		-158.0				
$PbCl_2 \cdot 8NH_3$	c	414.341		-248.3				
$2PbCl_2 \cdot NH_4Cl$	c	609.684		-247.25	-201.49		96.0	
$PbBr_2 \cdot NH_3$	c	384.039		-93.3				
$PbBr_2 \cdot 2NH_3$	c	401.069		-115.8				
$PbBr_2 \cdot 3NH_3$	c	418.100		-136.3				
$PbBr_2 \cdot 5.5NH_3$	c	460.676		-186.0				
$PbBr_2 \cdot 8NH_3$	c	503.253		-233.5				
$PbI_2 \cdot 1/2NH_3$	c	469.514		-54.8				
$PbI_2 \cdot NH_3$	c	478.029		-67.0				
$PbI_2 \cdot 2NH_3$	c	495.060		-89.3				
$PbI_2 \cdot 5NH_3$	c	546.152		-151.2				
$PbI_2 \cdot 8NH_3$	c	597.244		-207.0				
$3PbI_2 \cdot 4NH_4I$	c	1962.768		-314.0				
$3PbI_2 \cdot 4NH_4I \cdot 6H_2O$	c	2070.860		-734.0				
$PbSO_4 \cdot 2NH_3$	c	337.313		-262.8	-199.2		47.2	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 27(7) LEAD

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$PbSO_4 \cdot 4NH_3$	c	354.343		-302.4	-207.2		80.7	
$Pb(P_2O_7)^{2-}$ std. state, m = 1	aq	381.133			-479.8			
$Pb(P_2O_7)_2^{6-}$	aq	555.077		-1086.6				
$Pb_3(PO_4)_2$	c	811.513					84.4	61.25
$PbHPO_3$	c	287.170		-234.0				
$PbHPO_4$	c	303.169			-287.5			
$3PbI_2 \cdot PI_3$	c	1794.683		-132.0				
$3PbI_2 \cdot PI_3 \cdot 12H_2O$	c	2010.867		-976.9				
$3PbI_2 \cdot AsI_3$	c	1838.631		-111.6				
$3PbI_2 \cdot AsI_3 \cdot 12H_2O$	c	2054.815		-952.1				
$3PbI_2 \cdot SbI_3$	c	1885.460		-128.4				
$3PbI_2 \cdot SbI_3 \cdot 12H_2O$	c	2101.644		-977.3				
$PbCO_3$	c	267.199		-167.1	-149.5		31.3	20.89
PbC_2O_4	c	295.210		-203.5	-179.3		34.9	25.2
	aq						13.4	
$PbO \cdot PbCO_3$	c	490.389		-219.5	-195.2		48.8	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 27(8) LEAD

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Pb(CH_3)_4$	liq	267.330		23.4				
	g			32.48				
$Pb(CHCH_2)_4$	liq	315.375		213.				
$Pb(C_2H_5)_4$	liq	323.439		12.6				
	g			26.19				
$Pb(O_2CH)^+$ formate; std. state, m = 1	aq	252.208			-90.7			
$Pb(O_2CH)_2$ formate	c	297.226		-210.0				
ionized; std. state, m = 1	aq			-203.8	-173.57		46.	
undissoc.; std. state, m = 1	aq				-175.4			
$Pb(O_2CCH_3)^+$ acetate; std. state, m = 1	aq	266.235			-97.1			
$Pb(O_2CCH_3)_2$	c	325.280		-230.36				
ionized; std. state, m = 1	aq			-232.7	-182.41		43.7	
undissoc.; std. state, m = 1	aq				-186.4			
in 400 H_2O	aq			-231.76				
$Pb(O_2CCH_3)_2 \cdot 3H_2O$	c	379.326		-442.52				
$PbCl_2 \cdot PbCO_3$	c	545.295			-227.6			
$Pb(CN)_2 \cdot 2PbO \cdot H_2O$	c	723.620		-123.7				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 27(9) LEAD

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$PbCNS^+$	std. state, m = 1	aq	265.272			15.1			
$Pb(SCN)_2$	thiocyanate	c	323.354			32.1			
	undissoc.; std. state, m = 1	aq				36.9			
	ionized; std. state, m = 1	aq			36.1	38.47		71.5	
$PbSiO_3$		c	283.274		-273.83	-253.86		26.2	21.52
		amorp			-271.9				
Pb_2SiO_4		c	506.464		-325.8	-299.4		44.6	32.78
		amorp			-322.2				
$PbI_2 \cdot SnI_2$		c	833.498		-64.2				
$PbI_2 \cdot SnI_2 \cdot 8H_2O$		c	977.620		-630.9				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(1) BORON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
B β	c	10.811	0	0	0	0.290	1.40	2.65
	amorp			0.9		0.315	1.56+x	2.86
	g		133.28	134.5	124.0	1.511	36.65	4.971
B^+	g		324.64	327.34				
B^{++}	g		904.74	908.92				
B^{+++}	g		1779.43	1785.09				
B^{++++}	g		7760.6	7767.8				
B^{+++++}	g		15606.2	15614.9				
B_2	g	21.622	197.	198.5	185.0	2.094	48.23	7.30
BO	g	26.8104	5.26	6.	-1.	2.073	48.62	6.98
BO_2	g	42.8098	-71.99	-71.8	-73.1	2.553	54.84	10.28
BO_2^- std. state, m = 1	aq			-184.60	-162.27		-8.9	
B_2O_2	g	53.6208	-109.01	-108.7	-110.5	2.960	57.93	13.69
B_2O_3	c	69.6202	-302.731	-304.20	-285.30	2.223	12.90	15.04
	amorp			-299.84	-282.6		18.6	14.6
	g		-201.4	-201.67	-198.85	3.426	66.85	15.98
$B_4O_7^{--}$ std. state, m = 1	aq	155.2398			-622.6			
BH	g	11.8190	106.7	107.46	100.29	2.065	41.05	6.97
BH_3	g	13.8349		24.				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(2) BORON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)			
				kcal/mol			cal/deg mol	
BH_4^-	std. state, m = 1	aq	14.8429		11.51	27.31	26.4	
B_2H_6		g	27.6698	12.29	8.5	20.7	2.857	55.45	13.60
	in n-C_5H_{12}; std. state, x_2 = 1				6.0	23.0		39.4	
B_4H_{10}		g	53.3237		15.8			
B_5H_9		c	63.1267	13.626				
		liq			10.20	41.03	7.131	44.03	36.12
		g		24.40	17.5	41.8	3.662	65.92	23.13
B_5H_{11}		liq	65.1427		17.5			
		g			24.7			
B_6H_{10}		liq	74.9457		13.45			
		g			22.6			
$B_{10}H_{14}$		c	122.2216	-0.496	-10.8	45.9	6.762	42.20	52.09
		g		18.669	7.54	51.66	5.938	84.4	42.94
HBO_2	cubic	c	43.8178		-192.17			
	monoclinic	c			-189.83	-172.9		9.	
	orthorhombic	c			-188.52	-172.5		12.	
		g		-133.48	-134.3	-131.7	2.554	57.35	10.09
H_2BOH		g	29.8343			-64.		
$HB(OH)_2$		g	45.8337			-125.		

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(3) BORON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
H_3BO_3	c	61.8331	-258.312	-261.55	-231.60		21.23	19.45
	g			-237.6				
un-ionized; std. state, m = 1	aq			-256.29	-231.56		38.8	
in 60 H_2O	aq			-256.355				
100 H_2O				-256.338				
200 H_2O				-256.324				
500 H_2O				-256.314				
1,000 H_2O				-256.31				
5,000 H_2O				-256.304				
10,000 H_2O				-256.30				
$B(OH)_4^-$ std. state, m = 1	aq	78.8405		-321.23	-275.65		24.5	
$H_2BO_3 \cdot H_2O_2^-$ std. state, m = 1	aq	94.8399			-252.8			
$H_2BO_3 \cdot H_3BO_3 \cdot 2H_2O_2^-$ std. state, m = 1	aq	190.6877			-516.7			
$(BOH)_3$	g	83.4551		-289.				
$(HBO_2)_3$	g	131.4533		-544.				
$HB_4O_7^-$ std. state, m = 1	aq	156.2478			-641.8			
$H_2B_4O_7$ std. state, m = 1	aq	157.2557			-650.1			

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(4) BORON

Substance				ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
BF		g	29.8094	-29.93	-29.2	-35.8	2.078	47.89	7.07
BF_3		g	67.8062	-271.082	-271.75	-267.77	2.784	60.71	12.06
	in 50 H_2O	aq			-296.4				
	in nitrobenzene $C_6H_5NO_2$; std. state, $x_2 = 1$				-280.4	-265.9		25.3	
BF_4^-	std. state, m = 1	aq	86.8046		-376.4	-355.4		43.	
B_2F_4		g	97.6156	-343.48	-344.2	-337.1	4.08	75.8	18.90
BOF		g	45.8088		-145.				
$(BOF)_3$		g	137.4264		-568.				
HBF_4	in 14.67 HF + 58.72 H_2O	aq	87.8126		-375.5				
$B(OH)_2F$		g	63.8241		-249.7				
$BOHF_2$		g	65.8152		-260.9				
$BF_2(OH)_2^-$	std. state, m = 1	aq	82.8225			-320.5			
BF_3OH^-	std. state, m = 1	aq	84.8136		-365.0	-338.1		40.	
$B_3O_3FH_2$		g	101.4455		-383.				
$B_3O_3F_2H$		g	119.4360		-476.				
$B_3F_4O_3OH^{2-}$	std. state, m = 1	aq	173.4322		-753.5				
BCl		g	46.264	35.	35.73	28.90	2.118	50.94	7.57

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(5) BORON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
BCl_3	liq	117.170	-105.40	-102.1	-92.6	6.88	49.3	25.5
	g		-96.28	-96.50	-92.91	3.362	69.31	14.99
in $(CH_3)_2O$				-147.0				
CH_3COCl				-123.5				
$C_6H_5NO_2$				-110.8				
B_2Cl_4	liq	163.434		-125.0	-111.1		62.7	32.9
	g		-117.09	-117.2	-110.1	4.86	85.4	22.80
BOCl	g	62.2634		-75.				
$(BOCl)_3$	g	186.7902		-390.4	-370.5		91.	
$(BOCl)_4$	g	249.0536		-502.				
$B_3O_3H_2Cl$	g	117.9001		-314.				
$B_3O_3HCl_2$	g	152.3452		-339.				
$BClF_2$	g	84.2608		-212.8	-209.4		65.	
BCl_2F	g	100.7154		-154.2	-150.9		68.	
BBr	g	90.720	57.97	56.9	46.7	2.147	53.75	7.87
BBr_3	liq	250.538		-57.3	-57.0		54.9	
	g		-43.83	-49.15	-55.56	3.755	77.47	16.20
in $C_6H_5NO_2$				-69.8				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(6) BORON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$BBrF_2$	g	128.7168				3.054	68.42	13.49
$BFBr_2$	g	189.6274				3.386	74.06	14.89
BCl_2Br	g	161.626				3.477	74.16	15.39
$BClBr_2$	g	206.082				3.609	76.90	15.78
BI_3	g	391.5242	18.	17.00	4.96	4.024	83.43	16.92
BS	g	42.875	81.	81.74	69.02	2.085	51.65	7.18
BS_2	g	74.939		29.				
B_2S_2	g	85.750		36.				
B_2S_3	c	117.814		-57.5				
	g			16.				
$SF_4 \cdot BF_3$	c	175.8638		-484.				
BN	c	24.8177	-60.10	-60.8	-54.6	0.628	3.54	4.71
	g		154.	154.75	146.87	2.076	50.71	7.04
$(NH_3)_2 \cdot B_2H_6$	c	58.7074		-46.				
$NH_3 \cdot B_3H_7$ β, tetragonal; ammonia triborane	c	56.5194				6.727	39.63	50.
ammonia triborane	g						68.	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(7) BORON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$B_3N_3H_6$	liq	80.5009		-129.3	-93.88		47.7	
	g		-116.205	-122.31	-93.24	3.944	68.97	23.14
NH_4BO_2 std. state, m = 1	aq	60.8484		-216.27	-181.24		18.2	
in 220 H_2O	aq			-216.0				
NH_4BO_3	aq	76.8478		-195.4				
$NH_4BO_3 \cdot \frac{1}{2}H_2O$	c	85.8554		-238.3				
$NH_4B_5O_8 \cdot 4H_2O$	c	224.1519				47.365	92.97	85.34
$NH_3 \cdot BF_3$	c	84.8368		-323.6				
$B_3N_3H_3Cl_3$ β, trichloroborazole	c	183.8360		-255.0				
β, trichloroborazole	g			-237.8				
BP cubic	c	41.7848		-19.				
$B_{13}P_2$	c	202.4906		-40.				
$2PH_3 \cdot B_2H_6$	c	95.6652		-27.				
PF_3BH_3	g	101.8039		-204.1				
$POCl_3 \cdot BCl_3$	c	270.5022		-256.3	-220.1		74.	
$PH_3 \cdot BCl_3$	c	151.1677		-120.9	-93.6		46.	
BC	g	22.8222	197.					
BC_2	g	34.8333	181.					

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(8) BORON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
B_2C	g	33.6332	181.					
B_4C	c	55.2552	-16.93	-17.	-17.	1.343	6.48	12.62
$B(CH_3)_3$	liq	55.9162		-34.2	-7.7		57.1	
	g		-23.38	-29.7	-8.6	3.831	75.2	21.15
in $n\text{-}C_7H_{16}$				-34.5				
$C_6H_5NO_2$				-35.79				
$B(C_2H_5)_3$	liq	97.9974	-42.54	-46.5	2.2	13.02	80.47	57.65
	g			-37.69	3.80		104.6	
BH_3CO	g	41.8455	-25.056	-26.58	-22.2	3.090	59.57	14.21
$BH(OCH_3)_2$ dimethoxyborane	liq	73.8879		-144.7	-113.2		57.	
dimethoxyborane	g			-138.5	-113.2	4.36	77.4	21.01
$B(OCH_3)_3$ trimethoxyborane	liq	103.9144		-223.2	-178.0	11.45	67.8	45.89
trimethoxyborane	g			-215.0	-177.0		92.	
$B(OC_2H_5)_3$ triethoxyborane	liq	145.9958		-250.8				
triethoxyborane	g			-240.4				
$(CH_3)_2O \cdot 2B_2H_6$	g	101.4092		-30.	17.		156.	
$(CH_3)_2O \cdot BF_3$	liq	113.8757		-338.9				
	g			-328.5	-297.8		92.	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(9) BORON

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$(C_2H_5)_2O\cdot BF_3$	liq	141.9299		-354.3				
	g			-343.8				
$(CH_3O)_2BCl$ dimethoxychloroborane	liq	108.3329		-186.28				
dimethoxychloroborane	g			-178.2				
$B(OC_2H_5)Cl_2$	liq	126.7786		-157.5				
	g			-149.1				
$CH_3COCl\cdot BCl_3$	liq	195.6686		-168.2				
$B(OC_2H_5)_2Cl$	liq	136.3872		-205.6				
	g			-196.0				
$(CH_3)_2S\cdot BH_3$	liq	75.9690		-20.7	8.4		55.	
	g			-10.6	11.5		78.	
$(C_2H_5)_2S\cdot BH_3$	liq	104.0232		-40.8	1.6		75.0	
	g			-30.5	5.5		96.6	
$BH_3NH_2CH_3$	c	44.8928		-32.2				
$(CH_3)_3N\cdot BH_3$	c	72.9468		-34.06	16.85		44.7	
	g		-11.25	-20.3	20.8	5.27	77.6	30.58
$(CH_3)_3B\cdot NH_3$	c			-67.9	-19.0		52.	
	g			-54.1	-14.4		82.	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(10) BORON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$B(CH_3)_3 \cdot NH_2CH_3$	c	86.9741		-64.3	-10.5		68.	
	g			-52.6	-6.5		94.	
$(CH_3)_4N \cdot BH_4$	c	88.9898		-38.1	32.1		44.0	
std. state, m = 1	aq			-32.6	28.3		75.2	
$(CH_3)_3N \cdot B(CH_3)_3$	c	115.0281		-66.6	6.9		67.	
	g			-52.6	11.1		100.	
$(C_2H_5)_2NH \cdot B(CH_3)_3$	c	129.0552		-79.2				
	g			-62.9				
$(CH_3)_3NB_3H_7$	c	98.6007				8.732	54.60	51.98
$B(OCH_3)_3 \cdot NH_3$	c	120.9452		-254.				
$B(OCH_2CH_2)_3N$								
triethanolamine borate	c	156.9784				6.702	43.78	44.75
$(CH_3)_3N \cdot BF_3$	g	126.9181		-304.4				
$(CH_3)_3P \cdot B(CH_3)_3$	c	131.9952		-81.8				
	g			-68.3				
$BF_3 \cdot P(CH_3)_3$	c	143.8852		-327.4				
	g			-312.6				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(11) BORON

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$(CH_3)_3As \cdot B(CH_3)_3$	c	175.9430		-50.				
$(CH_3)_3As \cdot BF_3$	c	187.8330		-292.				
BSi	g	38.897	173.					
BSi_2	g	66.983	175.					
BSiC	g	50.9082	164.					
$PbO \cdot B_2O_3$ glassy	amorp	292.810		-365.6				26.5
$PbO \cdot 2B_2O_3$ glassy	amorp	362.430		-672.4				41.4

Table 29(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

ALUMINUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Al	c	26.9815	0	0	0	1.094	6.77	5.82
	g		77.44	78.0	68.3	1.654	39.30	5.11
Al^{+}	g		215.476	217.517				
Al^{2+}	g		649.663	653.185				
Al^{3+}	g		1305.70	1310.70				
std. state, m = 1	aq			-127.	-116.		-76.9	
Al^{4+}	g		4072.71	4079.19				
Al^{5+}	g		7619.73	7627.70				
Al^{6+}	g		12012.2	12021.7				
Al^{7+}	g		17592.7	17603.7				
Al^{8+}	g		24169.8	24182.2				
Al^{9+}	g		31785.	31799.				
Al^{10+}	g		40978.	40993.				
Al^{11+}	g		51170.	51187.				
Al_2	g	53.9630	116.	116.14	103.57	2.33	55.7	8.7
AlO	g	42.9809	21.83	21.8	15.6	2.101	52.17	7.38
AlO_2^- std. state, m = 1	aq	58.9803		-219.6	-196.8		-5.	
Al_2O	g	69.9624	-30.55	-31.	-38.	2.776	61.96	10.92
$(AlO)_2$	g	85.9618		-94.				

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Table 29(2) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — ALUMINUM

Substance				ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
Al_2O_3	α, corundum	c	101.9612	-397.59	-400.5	-378.2	2.394	12.17	18.89
	δ	c			-398.				
		c			-391.				
		c				-397.			
	γ	c			-395.				
		amorp			-390.				
$Al_2O_3 \cdot H_2O$	boehmite	c	119.9765		-472.0	-436.3		23.15	31.37
	diaspore	c			-478.	-440.		16.86	25.22
$Al_2O_3 \cdot 3H_2O$	gibbsite	c	156.0072		-612.5	-546.7		33.51	44.49
	bayerite	c			-610.1				
AlH		g	27.9895	62.	61.96	55.25	2.071	44.88	7.02
AlH_3		c	20.0054		-11.				
$AlOH^{2+}$	std. state, m = 1	aq	43.9889			-165.9			
$Al(OH)_3$		amorp	78.0036		-305.				
$Al(OH)_4^-$	std. state, m = 1	aq	95.0110		-356.2	-310.2		28.	
AlF		g	45.9799	-61.68	-61.7	-67.8	2.126	51.36	7.63
AlF^{2+}	std. state, m = 1	aq				-192.			
AlF_2^+	std. state, m = 1	aq			-266.				
AlF_3		c	83.9767	-358.02	-359.5	-340.6	2.778	15.88	17.95

Table 29(3) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

ALUMINUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
AlF_3	g		-287.01	-287.9	-284.0	3.37	66.2	14.97
un-ionized; std. state, m = 1	aq			-363.	-338.		-6.	
ionized; std. state, m = 1	aq			-366.	-316.		-86.8	
in 450 H_2O	aq			-365.5				
AlF_6^{3-}	aq	140.9719		-602.9				
Al_2F_6	g	167.9534		-628.				
AlOF	g	61.9793		-141.				
H_3AlF_6 in 800 HF + 8,000 H_2O		143.9958		-595.0				
AlCl	g	62.4345	-11.44	-11.4	-17.7	2.236	54.50	8.36
$AlCl_2$	g	97.8875		-79.				
$AlCl_3$	c	133.3405	-168.02	-168.3	-150.3	4.104	26.45	21.95
	g			-139.4				
std. state, m = 1	aq			-247.	-210.		-36.4	
in 1,000 H_2O	aq			-247.3				
3,000 H_2O	aq			-247.53				
5,000 H_2O	aq			-247.55				
10,000 H_2O	aq			-247.56				
30,000 H_2O	aq			-247.5				
50,000 H_2O	aq			-247.34				
100,000 H_2O	aq			-247.0				

Table 29(4) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

ALUMINUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$AlCl_3$ in 0.04185 HCl + 230 H_2O	aq			-246.57				
2.072 HCl + 230 H_2O	aq			-245.84				
4.144 HCl + 230 H_2O	aq			-245.08				
8.287 HCl + 230 H_2O	aq			-243.57				
12.431 HCl + 230 H_2O	aq			-242.05				
14.505 HCl + 230 H_2O	aq			-241.99				
16.575 HCl + 230 H_2O	aq			-240.52				
18.649 HCl + 230 H_2O	aq			-239.76				
0.1092 HCl + 600 H_2O	aq			-246.88				
5.405 HCl + 600 H_2O	aq			-246.13				
10.810 HCl + 600 H_2O	aq			-245.37				
21.619 HCl + 600 H_2O	aq			-243.85				
32.429 HCl + 600 H_2O	aq			-242.33				
37.834 HCl + 600 H_2O	aq			-241.56				
43.238 HCl + 600 H_2O	aq			-240.80				
48.643 HCl + 600 H_2O	aq			-240.02				
in $SiCl_4$, std. state, $x_2 = 1$				-165.5	-144.0		15.	
$AlCl_3 \cdot 6H_2O$	c	241.4325		-643.3				
Al_2Cl_6	g	266.6810		-308.5	-291.7		117.	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 29(5) ALUMINUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
AlOCl	c	78.4339		-189.2				
	g			-81.				
AlBr	g	106.8905	0.74	-1.	-10.	2.281	57.22	8.50
$AlBr_3$	c	266.7085		-126.0				24.3
	g			-101.6				
std. state, m = 1	aq			-214.	-191.		-17.8	
in 3,000 H_2O	aq			-214.2				
$HBr \cdot 8.5\ H_2O$	aq			-205.7				
C_2H_5Br				-126.5				
CH_3I				-126.1				
C_2H_5I				-126.9				
C_6H_6; benzene				-124.6				
$C_6H_5CH_3$; toluene				-125.3				
Al_2Br_6	g	533.4170		-232.0				
AlI	g	153.8859	16.	15.66		2.33		8.60
AlI_3	c	407.6947		-75.0	-71.9		38.	23.6
	g			-49.6				
	aq			-165.8				
std. state, m = 1	aq			-167.	-153.		2.9	

Table 29(6) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

ALUMINUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Al_2I_6	g	815.3894		-123.5				
AlS	g	59.0455	48.	48.02	35.88	2.172	55.09	7.98
Al_2S_3	c	150.1550		-173.				
$Al_2(SO_4)_3$	c	342.1478		-822.38	-740.95		57.2	62.00
	aq			-902.2				
std. state, m = 1	aq			-906.	-766.		-139.4	
$Al_2(SO_4)_3 \cdot 6H_2O$	c	450.2398		-1269.53	-1104.82		112.1	117.8
$Al_2(SO_4)_3 \cdot 18H_2O$	c	666.4239		-2122.1				
$AlCl_3 \cdot \frac{1}{2}SO_2$	c	165.3719		-212.9				
$AlCl_3 \cdot SO_2$	c	197.4033		-253.6				
$AlCl_3 \cdot H_2S$	c	167.4204		-182.4				
$AlBr_3 \cdot H_2S$	c	300.7884		-140.6				
$AlI_3 \cdot 2H_2S$	c	475.8546		-103.1				
Al_2Se_3	c	290.843		-135.				
Al_2Te_3	c	436.763		-78.				
AlN	c	40.9882	-74.80	-76.0	-68.6	0.925	4.82	7.20

Table 29(7) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

ALUMINUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Al(NO_3)_3$ std. state, m = 1 in 361.6 HCl + 4585 H_2O	aq	212.9962		-276.	-196.		28.1	
				-271.932				
$Al(NO_3)_3 \cdot 6H_2O$	c	321.0882		-681.28	-526.74		111.8	103.5
$Al(NO_3)_3 \cdot 9H_2O$	c	375.1343		-897.96				
$AlCl_3 \cdot NH_3$	c	150.3711		-212.6				
$AlCl_3 \cdot NH_4Cl$	c	186.8321		-256.8				
$AlCl_3 \cdot 3NH_3$	c	184.4323		-283.0				
$AlCl_3 \cdot 5NH_3$	c	218.4936		-339.2				
$AlCl_3 \cdot 6NH_3$	c	235.5242		-363.4				94.
$AlCl_3 \cdot 7NH_3$	c	252.5548		-384.6				
$AlCl_3 \cdot NH_4Cl \cdot 6NH_3$	c	289.0157		-445.4				
$AlCl_3 \cdot 14NH_3$	c	371.7690		-516.3				
$AlBr_3 \cdot NH_3$	c	283.7391		-177.6				
$AlBr_3 \cdot 3NH_3$	c	317.8003		-252.7				
$AlBr_3 \cdot 5NH_3$	c	351.8616		-316.2				
$AlBr_3 \cdot 6NH_3$	c	368.8922		-343.0				

Table 29(8) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

ALUMINUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$AlBr_3 \cdot 7NH_3$	c	385.9228		-364.7				
$AlBr_3 \cdot 9NH_3$	c	419.9840		-403.5				
$AlBr_3 \cdot 14NH_3$	c	505.1370		-497.2				
$AlI_3 \cdot NH_3$	c	424.7253		-119.0				
$AlI_3 \cdot 3NH_3$	c	458.7865		-205.9				
$AlI_3 \cdot 5NH_3$	c	492.8478		-287.9				
$AlI_3 \cdot 6NH_3$	c	509.8784		-312.9				
$AlI_3 \cdot 7NH_3$	c	526.9090		-335.6				
$AlI_3 \cdot 9NH_3$	c	560.9702		-374.9				
$AlI_3 \cdot 13NH_3$	c	629.0926		-450.0				
$AlI_3 \cdot 20NH_3$	c	748.3069		-580.8				
$NH_4Al(SO_4)_2$	c	237.1433		-562.2	-487.2		51.7	54.12
std. state, m = 1	aq			-593.	-491.		-40.2	
in 500 H_2O	aq			-591.24				
1,000 H_2O	aq			-591.64				
1,500 H_2O	aq			-591.82				
2,000 H_2O	aq			-592.02				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 29(9) ALUMINUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$NH_4Al(SO_4)_2$								
in 2,500 H_2O	aq			-592.21				
3,000 H_2O	aq			-592.40				
3,500 H_2O	aq			-592.54				
$NH_4Al(SO_4)_2 \cdot 12H_2O$	c	453.3274		-1420.26	-1180.21		166.6	163.3
$(NH_4)_2O \cdot 3Al_2O_3 \cdot 4SO_3 \cdot 6H_2O$	c	786.3010		-2408.7	-2125.3		164.2	185.3
$(NH_4)_2O \cdot 3Al_2O_3 \cdot 5SO_3 \cdot 9H_2O$	c	920.4101		-2759.3				
AlP	c	57.9553		-39.8				
$AlPO_4$ berlinite	c	121.9529	-411.40	-414.4	-382.7	3.528	21.70	22.27
$AlCl_3 \cdot PH_3$	c	167.3382		-176.9				
$AlBr_3 \cdot PH_3$	c	300.7062		-139.0				
$H_6(NH_4)_3Al_5(PO_4)_8 \cdot 18H_2O$ ammonium taranakite	c	1279.1184	-4364.85	-4433.0	-3863.9	57.185	339.9	380.5
AlAs	c	101.9031		-27.8				
Al_2C_2	g	77.9853	122.					
Al_4C_3	c	143.9594	-48.71	-49.9	-46.9	3.936	21.26	27.91
$Al(CH_3)_3$	c	72.0867	-29.76					
	liq			-32.6	-2.4	8.114	50.05	37.19
	g			-17.7				

Table 29(10) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity
ALUMINUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Al_2(CH_3)_6$	g	144.1734		-55.19	-2.34		125.4	
$(CH_3CO_2)_3Al$ aluminum triacetate	c	204.1165		-452.3				
$(CH_3)_2S \cdot Al(CH_3)_3$	liq	134.2208		-55.				
	g			-44.				
$(CH_3)_3N \cdot AlCl_3$	c	192.4524		-210.1				
$(CH_3)_3N \cdot AlBr_3$	c	325.8204		-170.0				
Al_2SiO_5 andalusite	c	162.0460	-651.84	-655.9	-620.8	4.086	22.28	29.33
kyanite	c		-652.09	-656.4	-620.5	3.834	20.03	29.09
sillimanite	c		-658.62	-662.6	-627.6	4.162	22.99	29.30
$Al_2Si_2O_7 \cdot 2H_2O$								
kaolinite	c	258.1615		-979.6	-903.0		48.5	58.62
halloysite	c			-975.1	-898.5		48.6	58.86
	c			-979.3	-902.3		47.1	57.24
$Al_6Si_2O_{13}$ mullite	c	426.0532		-1903.	-1811.		60.8	77.94
$2AlI_3 \cdot PbI_2$	c	2198.386		-234.				
$2AlI_3 \cdot 3PbI_2 \cdot 10H_2O$	c	2378.539		-1122.				
AlB_2	c	48.6035		-36.				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 29(11) ALUMINUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
AlB_{12} α	c	156.7135		-63.6				
$Al(BH_4)_3$	liq	71.5101		-3.9	34.6		69.1	46.5
	g			3.	35.		90.6	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 30(1) GALLIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Ga	c	69.72	0	0	0	1.331	9.77	6.18
	liq			1.33				
	g		66.	66.2	57.1	1.566	40.38	6.06
Ga^+	g		204.32	206.00				
Ga^{2+}	g		677.38	680.54				
std. state, m = 1	aq				-21.			
Ga^{3+}	g		1385.	1390.				
std. state, m = 1	aq			-50.6	-38.0		-79.	
Ga^{4+}	g		2865.	2871.				
Ga_2	g	139.44	105.	104.8				
GaO	g	85.719	67.	66.8	60.6	2.127	55.2	7.66
GaO_3^{3-} std. state, m = 1	aq	117.718			-148.			
Ga_2O	c	155.439		-85.				
	g			-21.				
Ga_2O_3 β, rhombic	c	187.438		-260.3	-238.6		20.31	22.00
GaH	g	70.728	53.	52.7	46.3	2.07	46.69	7.00
GaOH	g	86.727	-27.	-27.4				
$Ga(OH)^{2+}$ std. state, m = 1	aq				-90.9			
$HGaO_2^{2-}$ std. state, m = 1	aq	102.727			-164.			

Table 30(2) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

GALLIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Ga(OH)_2^+$ std. state, m = 1	aq	103.735			-142.8			
$H_2GaO_3^-$ std. state, m = 1	aq	119.734			-178.			
$Ga(OH)_3$	c	120.742		-230.5	-198.7		24.	
GaF	g	88.718	-60.	-60.2		2.167		7.95
GaF^{2+} std. state, m = 1	aq			-128.3	-111.1		-54.	
GaF_2^+ std. state, m = 1	aq	107.717		-206.3	-182.8		-35.	
GaF_3	c	126.715		-278.	-259.4		20.	
	aq			-288.1				
GaCl	g	105.173	-19.	-19.1	-25.4	2.29	57.4	8.50
$GaCl_3$	c	176.079		-125.4	-108.7		34.	
	g			-107.0				
	aq			-170.4				
$(GaCl_3)_2$	g	352.158		-233.1				
GaBr	g	149.629	-10.	-11.9	-21.5	2.37	60.2	8.70
$GaBr_3$	c	309.447		-92.4	-86.0		43.	
	g			-70.				
$GaBr_4^-$ std. state, m = 1	aq	389.356		-158.2	-131.5		8.6	
GaI	g	196.624	7.4	6.9		2.41		8.76

Table 30(3) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity
GALLIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
GaI_3	c	450.433		-57.1				
	g			-34.0				
$(GaI_3)_2$	g	900.866		-76.				
$Ga_2(SO_4)_3$	c	427.625						62.4
Ga_2Te_3	c	522.24						41.2
GaN	c	83.727		-26.4				
	g			42.	36.		54.	
$GaCl_3 \cdot NH_3$	c	193.110		-170.8				
	g			-150.1				
$GaCl_3 \cdot 3NH_3$	c	227.171		-230.7				
$GaCl_3 \cdot 5NH_3$	c	261.232		-285.5				
$GaCl_3 \cdot 6NH_3$	c	278.263		-307.9				
$GaCl_3 \cdot 7NH_3$	c	295.293		-328.3				
$GaCl_3 \cdot 14NH_3$	c	414.508		-460.				
$GaBr_3 \cdot NH_3$	c	326.478		-134.9				
$GaBr_3 \cdot 5NH_3$	c	394.600		-255.0				
$GaBr_3 \cdot 6NH_3$	c	411.631		-279.3				
$GaBr_3 \cdot 7NH_3$	c	428.661		-300.7				
$GaBr_3 \cdot 9NH_3$	c	462.724		-339.				
$GaBr_3 \cdot 14NH_3$	c	547.877		-432.				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 30(4) GALLIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$GaI_3 \cdot NH_3$	c	467.464		-96.2				
$GaI_3 \cdot 5NH_3$	c	535.586		-215.5				
$GaI_3 \cdot 6NH_3$	c	552.617		-241.7				
$GaI_3 \cdot 7NH_3$	c	569.647		-263.5				
$GaI_3 \cdot 9NH_3$	c	603.709		-302.5				
$GaI_3 \cdot 13NH_3$	c	671.831		-379.				
$GaI_3 \cdot 20NH_3$	c	791.045		-510.				
GaP	c	100.694		-21.				
$GaPO_4$	c	164.691			-310.1			
$GaCl_3 \cdot PCl_3$	c	313.412		-205.2				
$GaCl_3 \cdot POCl_3$	c	329.411		-278.3				
GaAs	c	144.642		-17.	-16.2		15.34	11.05
GaSb	c	191.47		-10.0	-9.3		18.18	11.60
Ga_2C_2	g	163.462		134.				
$Ga(CH_3)_3$	liq	114.825		-18.7				
	g			-10.8				
$GaCl_3 \cdot CH_3Cl$	c	226.567		-151.3				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 30(5) GALLIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$2GaCl_3 \cdot CH_3Cl$	c	402.646		-277.3				
$2GaCl_3 \cdot C_2H_5Cl$	c	414.873		-286.5				
$GaCl_3 \cdot CH_3COCl$	c	254.578		-194.9				
$GaCl_3 \cdot (CH_3)_2CO$	c	234.160		-200.0				
$GaCl_3 \cdot (C_2H_5)_2O$	c	250.203		-201.4				
$GaCl_3 \cdot 2(C_2H_5)_2O$	c	324.326		-274.2				
$GaBr_3 \cdot CH_3Br$	c	404.391		-107.5				
$2GaBr_3 \cdot CH_3Br$	c	713.838		-199.8				
$GaCH_3I_2$	c	338.564		-49.2				
$Ga(CH_3)_3 \cdot (CH_3)_2S$	liq	176.959		-45.1				
	g			-33.				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 31(1) INDIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
In	c	114.82	0	0	0	1.578	13.82	6.39
	g		58.25	58.15	49.89	1.48	41.51	4.98
In^+	g		191.68	193.06				
std. state, m = 1	aq				-2.9			
In^{2+}	g		626.82	629.68				
std. state, m = 1	aq				-12.1			
In^{3+}	g		1273.2	1277.56				
std. state, m = 1	aq			-25.	-23.4		-36.	
In^{4+}	g		2528.	2534.1				
In_2	g	229.64	91.7	91.04		2.50		
InO	g	130.819	92.	92.5	87.1	2.14	56.5	7.78
In_2O_3	c	277.638		-221.27	-198.55		24.9	22.
InH	g	115.828	52.	51.5	45.49	2.075	49.60	7.07
InOH	g	131.827	-18.	-19.				
$In(OH)^{2+}$ std. state, m = 1	aq			-88.5	-74.8		-21.	
$In(OH)_2^+$ std. state, m = 1	aq	148.835		-148.	-125.5		6.	
InF	g	133.818	-48.2	-48.61		2.198		
InCl II	c	150.273		-44.5				
	g			-18.				
$InCl_3$	c	221.179		-128.4				
	g			-89.4				

Table 31(2) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

INDIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
In_2Cl_3	g	335.999		-103.6				
InBr	c	194.729		-41.9	-40.4		27.	
	g		-11.5	-13.6	-22.54	2.406	61.99	8.76
$InBr_3$	c	354.547		-102.5				
	g			-67.4				
in $HCl \cdot 20H_2O$				-119.8				
InI	c	241.724		-27.8	-28.8		31.	
	g		2.52	1.8	-9.0	2.437	63.87	8.80
InI_3	c	495.533		-57.				
	g			-28.8				
InS	c	146.884		-33.0	-31.5		16.	
	g			90.		57.		
In_2S	g	261.704		15.	3.1		76.	
In_2S_3	c	325.832		-102.	-98.6		39.1	28.20
In_3S_4	c	472.716		-141.3				
In_4S_5	c	619.600		-180.				
$InSO_4^+$ std. state, m = 1	aq	210.882			-206.5			
$In_2(SO_4)_3$	c	517.825		-666.	-583.		65.	67.
InSe	c	193.78		-28.				
In_2Se_3	c	466.52		-82.				

Table 31(3) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

INDIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
InTe	c	242.42		-23.				
In_2Te_3	c	612.44		-47.				
InN	c	128.827		-4.2				
$InCl_3 \cdot NH_3$	c	238.210		-162.6				
$InCl_3 \cdot 2NH_3$	c	255.240		-195.0				
$InCl_3 \cdot 3NH_3$	c	272.271		-226.6				
$InCl_3 \cdot 5NH_3$	c	306.332		-274.5				
$InCl_3 \cdot 7NH_3$	c	340.393		-315.				
$InCl_3 \cdot 15NH_3$	c	476.638		-466.				
$InBr_3 \cdot 3NH_3$	c	405.639		-198.3				
$InBr_3 \cdot 5NH_3$	c	439.700		-251.3				
$InBr_3 \cdot 7NH_3$	c	473.761		-293.2				
$InBr_3 \cdot 15NH_3$	c	610.006		-450.				
$InI_3 \cdot 2NH_3$	c	529.594		-119.0				
$InI_3 \cdot 5NH_3$	c	580.686		-203.8				
$InI_3 \cdot 7NH_3$	c	614.747		-250.7				
$InI_3 \cdot 9NH_3$	c	648.809		-292.1				
$InI_3 \cdot 13NH_3$	c	716.931		-369.				
$InI_3 \cdot 21NH_3$	c	853.176		-520.				
InP	c	145.794		-21.2	-18.4		14.3	10.86

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 31(4) — INDIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
InAs	c	189.742		-14.0	-12.8		18.1	11.42
InSb	c	236.57		-7.3	-6.1		20.6	11.82
	g			82.3				
$InSb_2$	g	358.32		75.				
$(InC_2O_4)^+$ std. state, m = 1	aq	202.840			-192.3			
$In(C_2O_4)_2^-$ std. state, m = 1	aq	290.860			-368.			
$InCl_3 \cdot 2(CH_3)_2S$	c	345.447		-161.1				
$InBr_3 \cdot 2(CH_3)_2S$	c	478.815		-145.9				
$InI_3 \cdot 2(CH_3)_2S$	c	619.801		-79.				
$InSCN^{2+}$ std. state, m = 1	aq	172.902			14.4			
$In(CNS)_2^+$ std. state, m = 1	aq	230.984			16.1			
$In(CNS)_3$ un-ionized; std. state, m = 1	aq	289.066			39.4			

Table 32(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

THALLIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Tl	c	204.37	0	0	0	1.632	15.34	6.29
	g		43.701	43.55	35.24	1.481	43.225	4.968
in Hg	liq			0.076	-0.062		15.80	
Tl^+	g		184.553	185.883				
std. state, m = 1	aq			1.28	-7.74		30.0	
Tl^{2+}	g		655.636	658.447				
Tl^{3+}	g		1343.5	1347.8				
std. state, m = 1	aq			47.0	51.3		-46.	
Tl^{4+}	g		2513.	2519.				
Tl_2O	c	424.7394		-42.7	-35.2		30.	
Tl_2O_3	c	456.7382			-74.5			
Tl_2O_4	c	472.7376			-83.0			
TlOH	c	221.3774		-57.1	-46.8		21.	
in 350 H_2O	aq			-54.12				
500 H_2O	aq			-54.18				
750 H_2O	aq			-54.26				
1,000 H_2O	aq			-54.33				
1,500 H_2O	aq			-54.42				
2,000 H_2O	aq			-54.48				
∞ H_2O	aq			-53.69				

Table 32(2) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

THALLIUM

Substance				ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
TlOH	std. state, m = 1	aq			-53.69	-45.33		27.4	
	undissoc.; std. state, m = 1	aq				-46.4			
$TlOH^{2+}$	std. state, m = 1	aq				-3.8			
$Tl(OH)_2^+$	std. state, m = 1	aq	238.3848			-58.5			
$Tl(OH)_3$		c	255.3922			-121.2			
TlF		c	223.3684		-77.6				
		g			-43.6				
	std. state, m = 1	aq			-78.22	-74.38		26.7	
	undissoc.; std. state, m = 1	aq				-74.5			
	in 800 H_2O	aq			-78.5				
$TlHF_2$		c	243.3748				4.308	34.92	21.25
	in 800 H_2O	aq			-154.3				
TlCl		c	239.8230	-49.091	-48.79	-44.20	3.030	26.59	12.17
		g			-16.2				
	std. state, m = 1	aq			-38.67	-39.11		43.5	
	undissoc.; std. state, m = 1	aq			-41.10	-39.91		41.3	
$TlCl^{2+}$	std. state, m = 1	aq			1.0	9.7		-19.	
$TlCl_2^+$	std. state, m = 1	aq	275.2760		-43.0	-29.6		7.	
$TlCl_2^-$	std. state, m = 1	aq				-70.7			
$TlCl_3$		c	310.7290		-75.3				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 32(3) THALLIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$TlCl_3$	aq			-84.0				
std. state, m = 1	aq			-72.9	-42.8		-5.5	
undissoc.; std. state, m = 1	aq			-84.0	-65.6		32.	
$TlCl_3 \cdot 4H_2O$	c	382.7906		-359.4				
$TlCl_4^-$ std. state, m = 1	aq	346.1820		-124.1	-100.8		58.	
Tl_2Cl_2	g	479.6460		-49.4				
$TlClO_3$ std. state, m = 1	aq	287.8212		-22.4	-8.5		68.8	
undissoc.; std. state, m = 1	aq				-9.18			
TlBr	c	284.2790		-41.4	-40.00		28.8	
	g			-9.0				
std. state, m = 1	aq			-27.77	-32.59		49.7	
undissoc.; std. state, m = 1	aq			-30.22	-33.90		45.93	
$TlBr^{2+}$ std. state, m = 1	aq			9.0	13.5		-13.	
$TlBr_2^+$ std. state, m = 1	aq	364.1880		-26.1	-21.4		20.	
$TlBr_2^-$ std. state, m = 1	aq			-53.8	-58.8		84.	
$TlBr_3$	aq	444.0970		-59.7				
std. state, m = 1	aq			-40.2	-23.2		13.	
undissoc.; std. state, m = 1	aq			-59.7	-53.7		49.	
$TlBr_3 \cdot 4H_2O$	c	516.1586		-335.2				
$TlBr_4^-$ std. state, m = 1	aq	524.0060		-90.9	-84.2		80.	

Table 32(4) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

THALLIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$TlBrO_3$	c	332.2772		-32.6	-12.70		40.3	
std. state, m = 1	aq			-18.7	-7.3		69.0	
$TlBrCl^-$ std. state, m = 1	aq	319.7320			-65.1			
$TlCl_2Br$	aq	355.1850		-75.9				
$TlCl_2Br \cdot 4H_2O$	c	427.2466		-352.0				
$TlBr_2Cl$	aq	399.6410		-67.8				
$TlClBr_2 \cdot 4H_2O$	c	471.7026		-344.1				
TlI	c	331.2744		-29.6	-29.97		30.5	
	g			1.7				
std. state, m = 1	aq			-11.91	-20.07		56.6	
undissoc.; std. state, m = 1	aq				-22.1			
TlI_2^- std. state, m = 1	aq	458.1788			-35.1			
TlI_4^- std. state, m = 1	aq	711.987			-39.3			
$TlIO_3$	c	379.2726		-63.9	-45.86		42.2	
std. state, m = 1	aq			-51.6	-38.3		58.3	
$TlIBr^-$ std. state, m = 1	aq	411.1834			-48.0			
Tl_2S	c	440.8040		-23.2	-22.4		36.	
$TlSO_4^-$ std. state, m = 1	aq	300.4316		-216.26	-187.6		40.	
Tl_2SO_4	c	504.8016		-222.7	-198.49		55.1	
std. state, m = 1	aq			-214.76	-193.45		64.8	

Table 32(5) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

THALLIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$TlHSO_4$ in $H_2SO_4 \cdot 30H_2O$	aq	301.4395		-212.4				
Tl_2Se	c	533.6824		-14.	-14.1		41.	
Tl_2SeO_4	c	551.6976		-151.	-126.4		56.	
$Te(SeO_3)_3$	c	789.6146			-215.4			
Tl_2Te	c	536.3400		-22.				
TlN_3	c	246.3901		55.8	70.38		35.1	
$TlNO_3$	c	266.3749		-58.30	-36.44		38.4	23.78
std. state, m = 1	aq			-48.28	-34.35		65.0	
undissoc.; std. state, m = 1	aq			-48.93	-34.85		64.5	
$TlNO_3^{2+}$ std. state, m = 1	aq				21.6			
$TlNH_3^+$ std. state, m = 1	aq	221.4007			-12.9			
$TlCl \cdot 3NH_3$	c	290.9151		-102.6				
$TlCl_3 \cdot 3NH_3$	c	361.8211		-135.0				
$TlBr \cdot 3NH_3$	c	335.3711		-95.3				
$TlI \cdot 3NH_3$	c	382.3665		-83.5				
Tl_2CO_3	c	468.7493		-167.3	-146.9		37.1	
$TlOCH_3$	c	235.4045		-27.5				
$Tl(CH_3CO_2)$	c	263.4150		-126.1				
	aq			-115.8				

Table 32(6) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

THALLIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Tl(CH_3CO_2)$ std. state, m = 1	aq			-114.88	-96.03		50.7	
$TlOC_2H_5$	liq	249.4311		-56.5				
	aq			-56.0				
$Tl(CN)_4^-$ std. state, m = 1	aq	308.4412			168.			
TlONC thallous fulminate	c	246.3872		27.6				
TlCNS	c	262.4518		6.8	9.21		39.	
std. state, m = 1	aq			19.55	14.41		64.5	
undissoc.; std. state, m = 1	aq			16.59	13.32		58.2	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 33(1) ZINC

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Zn	c	65.37	0	0	0	1.350	9.95	6.07
	g		31.114	31.245	22.748	1.481	38.450	4.968
in Hg	c			0	0		9.95	
Zn^+	g		247.740	249.352				
Zn^{2+}	g		662.00	665.09				
std. state, m = 1	aq			-36.78	-35.14		-26.8	11.
Zn^{3+}	g		1577.8	1582.4				
ZnO	c	81.369		-83.24	-76.08		10.43	9.62
ZnO_2^{2-} std. state, m = 1	aq	97.369			-91.85			
$ZnO_2 \cdot 2H_2O$	c	133.399		-207.6				
$ZnO \cdot 2ZnO_2 \cdot 2H_2O$	c	312.138		-573.5				
$ZnO \cdot 2ZnO_2 \cdot 3H_2O$	c	330.153		643.6				
$ZnOH^+$ std. state, m = 1	aq	87.377			-78.9			
$HZnO_2^-$ std. state, m = 1	aq	98.377			-109.26			
$Zn(OH)_2$ γ	c	99.385			-132.38			
β	c			-153.42	-132.31		19.4	
e	c			-153.74	-132.68		19.5	17.3
precipitated				-153.5				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 33(2) ZINC

Substance				ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$Zn(OH)_2$	std. state, m = 1	aq			-146.72	-110.33		-31.9	-60.
	undissoc.; std. state, m = 1	aq				-124.95			
$Zn(OH)_3^-$	std. state, m = 1	aq	116.392			-165.95			
$Zn(OH)_4^{2-}$	std. state, m = 1	aq	133.399			-205.23			
ZnF^+	std. state, m = 1	aq	84.368			-103.49			
ZnF_2		c	103.367	-182.06	-182.7	-107.5	2.821	17.61	15.69
	std. state, m = 1	aq			-195.78	-168.42		-33.4	-40.
$ZnCl^+$	std. state, m = 1	aq	100.823			-65.8			
$ZnCl_2$		c	136.276	-99.255	-99.20	-88.296	3.598	26.64	17.05
		g			-63.6				
	std. state, m = 1	aq			-116.68	-97.88		0.2	-54.
	undissoc.; std. state, m = 1	aq				-96.5			
	in 4 H_2O	aq			-105.90				
	5 H_2O	aq			-107.59				
	6 H_2O	aq			-108.06				
	7 H_2O	aq			-108.40				
	8 H_2O	aq			-108.70				
	10 H_2O	aq			-109.17				
	12 H_2O	aq			-109.57				
	15 H_2O	aq			-110.03				
	20 H_2O	aq			-110.66				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 33(3) ZINC

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
in 25 H_2O	aq			-111.14				
30 H_2O	aq			-111.55				
40 H_2O	aq			-112.20				
50 H_2O	aq			-112.70				
75 H_2O	aq			-113.75				
100 H_2O	aq			-114.24				
200 H_2O	aq			-115.18				
400 H_2O	aq			-115.62				
500 H_2O	aq			-115.72				
1,000 H_2O	aq			-116.02				
∞ H_2O	aq			-116.68				
in HCl(aq)	aq			-110.2				
in 300 C_2H_5OH				-109.0				
$ZnCl_3^-$ std. state, m = 1	aq	171.729			-129.2			
$ZnCl_4^{2-}$ std. state, m = 1	aq	207.182			-159.2			
$ZnClO_4^+$ std. state, m = 1	aq	164.821			-39.0			
$Zn(ClO_4)_2$ std. state, m = 1	aq	264.271		-98.60	-39.26		60.2	
in 7 H_2O	aq			-96.25				
8 H_2O	aq			-96.45				
9 H_2O	aq			-96.68				
11 H_2O	aq			-97.03				

Table 33(4) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity
ZINC

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Zn(ClO_4)_2$ in 12 H_2O	aq			-97.29				
15 H_2O	aq			-97.54				
20 H_2O	aq			-97.78				
30 H_2O	aq			-98.05				
50 H_2O	aq			-98.10				
75 H_2O	aq			-98.15				
100 H_2O	aq			-98.20				
200 H_2O	aq			-98.27				
500 H_2O	aq			-98.60				
1,000 H_2O	aq			-98.6				
$Zn(ClO_4)_2 \cdot 6H_2O$	c	372.363		-509.89	-371.8		130.4	
$ZnCl_2 \cdot 3ZnO \cdot 5H_2O$	c	470.461		-689.4				
$ZnCl_2 \cdot 4ZnO \cdot 11H_2O$	c	659.922		-1183.4				
$ZnCl_2 \cdot 5ZnO \cdot 8H_2O$	c	687.246		-1059.3				
$ZnCl_2 \cdot 8ZnO \cdot 10H_2O$	c	967.385		-1441.4				
Zn(OH)Cl undissoc.; std. state, m = 1	aq	117.830			-113.0			
$Zn_2(OH)_3Cl$	c	217.215			-251.0			
$ZnBr^+$ std. state, m = 1	aq	145.279			-59.2			
$ZnBr_2$	c	225.188		-78.55	-74.60		33.1	
std. state, m = 1	aq			-94.88	-84.84		12.6	-57.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 33(5) ZINC

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$ZnBr_2$	undissoc.; std. state, m = 1	aq			-83.5			
	in 400 H_2O	aq		-93.78				
$ZnBr_2 \cdot 2H_2O$		c	261.219	-224.0	-191.1		47.5	
$ZnBr_3^-$	std. state, m = 1	aq	305.097		-107.3			
$ZnBr_2 \cdot 4ZnO \cdot 13H_2O$		c	784.865	-1299.4				
ZnI^+	std. state, m = 1	aq	192.274		-43.5			
ZnI_2		c	319.179	-49.72	-49.94		38.5	
	std. state, m = 1	aq		-63.16	-59.80		25.2	-57.
	undissoc.; std. state, m = 1	aq			-57.5			
	in 3,000 H_2O	aq		-61.4				
ZnI_3^-	std. state, m = 1	aq	446.083		-69.7			
ZnI_4^{2-}	std. state, m = 1	aq	-572.988		-81.3			
$Zn(IO_3)_2$		c	415.175		-103.68			
	std. state, m = 1	aq		-142.6	-96.3		29.8	
$ZnI_2 \cdot 5ZnO \cdot 11H_2O$		c	924.194	-1185.4				
ZnS	wurtzite	c	97.434	-46.04				
	sphalerite	c		-49.23	-48.11		13.8	11.0
$ZnSO_4$		c	161.432	-234.9	-209.0		28.6	

Table 33(6) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

ZINC

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$ZnSO_4$ std. state, m = 1	aq			-254.10	-213.11		-22.0	-59.
undissoc.; std. state, m = 1	aq			-250.4	-216.3		1.2	
in 15 H_2O	aq			-251.889				
20 H_2O	aq			-252.258				
25 H_2O	aq			-252.553				
30 H_2O	aq			-252.653				
40 H_2O	aq			-252.756				
50 H_2O	aq			-252.799				
75 H_2O	aq			-252.856				
100 H_2O	aq			-252.897				
150 H_2O	aq			-252.950				
200 H_2O	aq			-253.004				
300 H_2O	aq			-253.033				
400 H_2O	aq			-253.071				
500 H_2O	aq			-253.108				
750 H_2O	aq			-253.176				
1,000 H_2O	aq			-253.225				
1,500 H_2O	aq			-253.294				
2,000 H_2O	aq			-253.343				
3,000 H_2O	aq			-253.382				
5,000 H_2O	aq			-253.503				

Table 33(7) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

ZINC

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
in 7,500 H_2O	aq			-253.577				
10,000 H_2O	aq			-253.628				
15,000 H_2O	aq			-253.687				
20,000 H_2O	aq			-253.740				
30,000 H_2O	aq			-253.807				
50,000 H_2O	aq			-253.879				
100,000 H_2O	aq			-253.948				
200,000 H_2O	aq			-254.000				
500,000 H_2O	aq			-254.044				
1,000,000 H_2O	aq			-254.065				
∞ H_2O	aq			-254.10				
$ZnSO_4 \cdot H_2O$	c	179.447		-311.78	-270.58		33.1	
$ZnSO_4 \cdot 6\,H_2O$	c	269.524		-663.83	-555.64		86.9	85.49
$ZnSO_4 \cdot 7\,H_2O$	c	287.539		-735.60	-612.59		92.9	91.64
ZnS_2O_6	aq	225.494		-323.2				
$ZnS_2O_6 \cdot 6\,H_2O$	c	333.586		-735.2				
$ZnO \cdot 2\,ZnSO_4$	c	404.233		-551.3	-492.1		66.9	
$ZnSO_4 \cdot Zn(OH)_2$	c	260.816			-351.4			
ZnSe	c	144.33		39.	39.		20.	
$ZnSeO_3$ std. state, m = 1	aq	192.328		-158.5	-123.5		-23.7	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 33(8) ZINC

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$ZnSeO_3 \cdot H_2O$	c	210.344		-222.5	-189.5		39.	
$ZnSeO_4$	c	208.328		-158.8				
std. state, m = 1	aq			-180.0	-140.6		-13.9	
in 1,200 H_2O	aq			-176.24				
$ZnSeO_4 \cdot H_2O$	c	226.343		-234.9				
$ZnSeO_4 \cdot 6H_2O$	c	316.420		-587.5				
ZnTe	c	192.97		-28.1				
ZnN_3^+ std. state, m = 1	aq	107.390			47.4			
$Zn(N_3)_2$	c	149.410		52.				
undissoc.; std. state, m = 1	aq				129.6			
Zn_3N_2	c	224.123		-5.4				26.
$Zn(NO_3)_2$	c	189.380		-115.6				
ionized; std. state, m = 1	aq			-135.90	-88.36		43.2	-30.
in 1.5 H_2O	aq			-121.1				
2.0 H_2O	aq			-122.8				
2.5 H_2O	aq			-124.2				
3.0 H_2O	aq			-125.6				
3.5 H_2O	aq			-126.8				
4.0 H_2O	aq			-128.0				
4.5 H_2O	aq			-128.9				

Table 33(9) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

ZINC

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Zn(NO_3)_2$ in 5 H_2O	aq			-129.8				
6 H_2O	aq			-131.2				
7 H_2O	aq			-132.2				
8 H_2O	aq			-133.0				
9 H_2O	aq			-133.6				
10 H_2O	aq			-133.99				
12 H_2O	aq			-134.54				
15 H_2O	aq			-134.99				
20 H_2O	aq			-135.26				
25 H_2O	aq			-135.36				
30 H_2O	aq			-135.43				
50 H_2O	aq			-135.56				
100 H_2O	aq			-135.67				
200 H_2O	aq			-135.63				
500 H_2O	aq			-135.51				
1,000 H_2O	aq			-135.54				
2,000 H_2O	aq			-135.6				
∞ H_2O	aq			-135.90				
$Zn(NO_3)_2 \cdot H_2O$	c	207.395		-192.4				
$Zn(NO_3)_2 \cdot 2H_2O$	c	225.410		-265.36				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 33(10) ZINC

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Zn(NO_3)_2 \cdot 4H_2O$	c	261.441		-406.10				
$Zn(NO_3)_2 \cdot 6H_2O$	c	279.472		-551.30	-423.79		109.2	77.2
$Zn(NH_3)^{2+}$ std. state, m = 1	aq	82.401			-44.4			
$Zn(NH_2)_2$	c	97.415		-38.2				
$Zn(N_2H_4)^{2+}$ std. state, m = 1	aq	97.415			-8.8			
$Zn(NH_3)_2^{2+}$ std. state, m = 1	aq	99.431			-53.8			
$Zn(NH_3)_3^{2+}$ std. state, m = 1	aq	116.462			-63.2			
$Zn(N_2H_4)_2^{2+}$ std. state, m = 1	aq	129.461			21.4			
$Zn(NH_3)_4^{2+}$ std. state, m = 1	aq	133.492		-127.5	-72.2		72.	
$Zn(N_2H_4)_3^{2+}$ std. state, m = 1	aq	161.506			51.9			
$Zn(N_2H_4)_4^{2+}$ std. state, m = 1	aq	193.551			82.4			
$Zn(NH_3)_4(NO_3)_2$	aq	257.502		-227.4				
$Zn(NO_3)_2 \cdot 4Zn(OH)_2$	c	586.919			-624.4			
$ZnCl_2 \cdot NH_3$	c	153.307		-134.0				
$ZnCl_2 \cdot 2NH_3$	c	170.337		-161.9	-120.3		63.1	
$ZnCl_2 \cdot 2N_2H_4$	c	200.367		-114.79				

Table 33(11) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

ZINC

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$ZnCl_2 \cdot 4NH_3$	c	204.398		-207.7	-132.7		90.4	
$ZnCl_2 \cdot 4NH_3 \cdot 1/2H_2O$	c	213.406		-243.9				
$ZnCl_2 \cdot 5NH_3 \cdot H_2O$	c	239.444		-290.6				
$ZnCl_2 \cdot 6NH_3$	c	238.460		-251.7	-142.8		116.3	
$3ZnCl_2 \cdot 6NH_4Cl \cdot H_2O$	c	747.793		-832.6				
$ZnCl_2 \cdot 8NH_4Cl \cdot ZnO$	c	645.578		-769.3				
$3ZnCl_2 \cdot 10NH_4Cl \cdot ZnO$	c	1025.113		-1055.9				
$6ZnCl_2 \cdot 12NH_3 \cdot ZnO$	c	1103.393		-975.3				
$ZnBr_2 \cdot NH_3$	c	242.219		-112.5				
$ZnBr_2 \cdot 2NH_3$	c	259.249		-141.5				
$ZnBr_2 \cdot 2N_2H_4$	c	289.279		-95.72				
$ZnBr_2 \cdot 4NH_3$	c	293.310		-193.8				
$ZnBr_2 \cdot 6NH_3$	c	327.372		-239.5				
$ZnBr_2 \cdot 6NH_3 \cdot H_2O$	c	345.387		-311.6				
$ZnI_2 \cdot NH_3$	c	336.209		-84.0				
$ZnI_2 \cdot 2NH_3$	c	353.240		-113.8				
$ZnI_2 \cdot 2N_2H_4$	c	383.269		-63.16				

Table 33(12) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

ZINC

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$ZnI_2 \cdot 4NH_3$	c	387.301		-165.8				
$ZnI_2 \cdot 6NH_3$	c	421.363		-211.2				
$ZnSO_4 \cdot (NH_4)_2SO_4$	c	293.570		-526.2				
$ZnSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$	c	401.662		-955.2				
Zn_3P_2	c	258.058		-113.				
$Zn(PO_3)_2$	c	223.314		-497.9				
	amorp			-485.3				
$Zn_2(P_2O_7)$	c	304.683		-600.0				
$Zn_3(PO_4)_2$	c	386.053		-691.3				
$Zn_3P_4O_{13}$	amorp	527.997		-1070.6				
$Zn_5(P_3O_{10})_2$	amorp	832.681		-1653.1				
$ZnAs_2$	c	215.213		-7.6				
Zn_3As_2	c	345.953		-0.8				
$Zn_3(AsO_4)_2$	c	473.948			-453.			
ZnSb	c	187.12		-3.5				
$ZnCO_3$	c	125.379		-194.26	-174.85		19.7	19.05
$ZnCO_3 \cdot H_2O$	c	143.395			-232.0			

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 33(13) ZINC

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
ZnC_2O_4 std. state, m = 1	aq	153.390		-234.0	-196.2		-15.9	
undissoc.; std. state, m = 1	aq				-203.0			
$ZnC_2O_4 \cdot 2H_2O$	c	189.420		-374.0	-321.7		46.7	
$Zn(C_2O_4)_2^{2-}$ std. state, m = 1	aq	241.410		-430.7	-367.5		31.	
$Zn(CH_3)_2$	liq	95.440		5.6				
	g			12.67				
$Zn(C_2H_5)_2$	liq	123.494		2.5				
	g			12.1				
$Zn(CHO_2)^+$ std. state, m = 1	aq	110.388		-119.8				
$Zn(CHO_2)_2$	c	155.406		-235.8				
std. state, m = 1				-240.20	-202.9		17.	
undissoc.; std. state, m = 1	aq				-204.2			
in 500 H_2O	aq			-239.8				
$Zn(CHO_2)_2 \cdot 2H_2O$	c	191.437		-378.8				
$Zn(CHO_2)_3^-$ std. state, m = 1	aq	200.424			-287.5			
$Zn(CHO_2)_4^{2-}$ std. state, m = 1	aq	245.442			-371.7			
$Zn(C_2H_3O_2)_2$ acetate	c	183.460		-257.8				
std. state, m = 1	aq			-269.10	-211.72		14.6	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 33(14) ZINC

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$Zn(C_2H_3O_2)_2$ in 50 H_2O	aq			-264.0				
100 H_2O	aq			-265.8				
200 H_2O	aq			-266.2				
400 H_2O	aq			-267.1				
800 H_2O	aq			-267.56				
$Zn(C_2H_3O_2)_2 \cdot H_2O$	c	201.475		-328.9				
$Zn(C_2H_3O_2)_2 \cdot 2H_2O$	c	219.491		-399.7				
$Zn(CH_2OHCOO)_2$	c	215.459		-350.6				
in 200 H_2O	aq			-350.5				
$Zn(CH_2OHCOO)_2 \cdot H_2O$	c	233.474		-422.4				
$Zn(CN)_2$	c	117.406		22.9				
$Zn(CN)_4^{2-}$ std. state, m = 1	aq	169.441		81.8	106.8		54.	
$3Zn(CN)_2 \cdot ZnO$	c	433.586		-13.8				
$Zn(NH_2CH_2CH_2NH_2)^{2+}$	aq	125.469		-56.8				
$Zn(NH_2CH_2CH_2NH_2)_2^{2+}$	aq	185.569		-77.2				
$Zn(NH_2CH_2CH_2NH_2)_3^{2+}$	aq	245.668		-97.4				
$Zn(CH_3CO_2)_2 \cdot NH_3$	c	200.491		-287.5				
$Zn(CH_3CO_2)_2 \cdot 2NH_3$	c	217.521		-311.3				
$Zn(CH_2OHCOO)_2 \cdot 2NH_3$	c	249.520		-404.8				
$Zn(CH_3CO_2)_2 \cdot 4NH_3$	c	251.582		-353.5				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 33(15) ZINC

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Zn(CH_2OHCOO)_2 \cdot 4NH_3$	c	283.581		-449.7				
$Zn(CH_3CO_2)_2 \cdot 6NH_3$	c	285.644		-393.9				
$Zn(CH_2OHCOO)_2 \cdot 6NH_3$	c	317.642		-490.1				
$Zn(CH_3CO_2)_2 \cdot 8NH_3$	c	319.705		-434.1				
$ZnCl_2 \cdot NH_2CH_2CH_2NH_2$	c	196.375		-136.0				
$ZnCl_2 \cdot 3NH_2CH_2CH_2NH_2$	c	316.574		-173.8				
$ZnBr_2 \cdot NH_2CH_2CH_2NH_2$	c	285.287		-106.7				
$ZnBr_2 \cdot 3NH_2CH_2CH_2NH_2$	c	405.486		-157.2				
$ZnI_2 \cdot NH_2CH_2CH_2NH_2$	c	379.278		-85.6				
$ZnI_2 \cdot 3NH_2CH_2CH_2NH_2$	c	499.477		-129.3				
$Zn(CNS)_2$ undissoc.; std. state, m = 1	aq	181.534			7.9			
$Zn(CNS)_4^{2-}$ std. state, m = 1	aq	297.697			51.7			
$Zn(NH_3)_2CS_3$	c	207.634		-82.9	-44.0		43.	
$ZnSiO_3$	c	141.454		-301.2				
Zn_2SiO_4	c	222.824		-391.19	-364.06		31.4	29.48
$PbI_2 \cdot 2ZnI_2$	c	1099.356		-140.6				
$Zn(BO_2)_2$	c	150.990			-373.58			
$ZnAl_2O_4$	c	183.331		-502.2				
$Al_2Cl_6 \cdot 3/2ZnCl_2$	c	471.095		-476.3				

Table 34(1) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CADMIUM

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
Cd	v	c	112.40	0	0	0	1.491	12.37	6.21
	α	c			-0.14	-0.14		12.37	
		g		26.78	26.77	18.51	1.481	40.066	4.968
	in Hg; two-phase amalgam				-5.078	-2.328		3.145	
Cd^+		g		234.18	235.65				
Cd^{2+}		g		624.09	627.04				
	std. state, m = 1	aq			-18.14	-18.542		-17.5	
CdO		c	128.399		-61.7	-54.6		13.1	10.38
CdO_2^{2-}	std. state, m = 1	aq	162.414			-68.0			
$CdOH^+$	std. state, m = 1	aq	129.407			-62.4			
$HCdO_2^-$	std. state, m = 1	aq	161.406			-86.9			
$Cd(OH)_2$	precipitated	c	146.415		-134.0	-113.2		23.	
	std. state, m = 1	aq			-128.08	-93.73		-22.6	
	undissoc.; std. state m = 1	aq				-105.8			
$Cd(OH)_3^-$	std. state, m = 1	aq	163.422			-143.6			
$Cd(OH)_4^{2-}$	std. state, m = 1	aq	180.429			-181.3			
CdF_2		c	150.397		-167.4	-154.8		18.5	
	std. state, m = 1	aq			-172.14	-151.82		-24.1	
$CdCl^+$	std. state, m = 1	aq	147.853		-57.5	-53.63		10.4	

Table 34(2) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CADMIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$CdCl_2$	c	183.306	-93.677	-93.57	-82.21	3.791	27.55	17.85
std. state, m = 1	aq			-98.04	-81.286		9.5	
undissoc.; std. state, m = 1	aq			-96.8	-85.88		29.1	
in 200 H_2O	aq			-96.863				
400 H_2O	aq			-97.024				
500 H_2O	aq			-97.069				
800 H_2O	aq			-97.154				
1,000 H_2O	aq			-97.192				
2,000 H_2O	aq			-97.310				
3,000 H_2O	aq			-97.378				
5,000 H_2O	aq			-97.462				
10,000 H_2O	aq			-97.608				
50,000 H_2O	aq			-97.878				
100,000 H_2O	aq			-97.932				
∞ H_2O	aq			-98.04				
$CdCl_2 \cdot H_2O$	c	201.321		-164.54	-140.310		40.1	
$CdCl_2 \cdot 5/2H_2O$	c	228.344		-270.54	-225.644		54.3	
$CdCl_3^-$ std. state, m = 1	aq	218.759		-134.1	-116.4		48.5	

Table 34(3) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity
CADMIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Cd(ClO_4)_2$ std. state, m = 1	aq	311.301		-79.96	-22.66		69.5	
in 6.7 H_2O	aq			-76.6				
10 H_2O	aq			-78.3				
20 H_2O	aq			-79.2				
30 H_2O	aq			-79.5				
50 H_2O	aq			-79.8				
100 H_2O	aq			-79.9				
1,000 H_2O	aq			-79.9				
$Cd(ClO_4)_2 \cdot 6H_2O$	c	419.393		-490.6				
$CdCl_2 \cdot 2HCl \cdot 7H_2O$	c	382.335		-654.8				
Cd(OH)Cl	c	164.860		-119.0	-101.8		21.	
undissoc.; std. state, m = 1	aq				-96.5			
$CdBr^+$ std. state, m = 1	aq	192.309		-48.0	-46.35		9.5	
$CdBr_2$	c	272.218	-72.455	-75.57	-70.82	4.235	32.8	18.32
std. state, m = 1 1	aq			-76.24	-68.24		21.9	
undissoc.; std. state, m = 1	aq				-72.2			
in 13.45 H_2O	aq			-76.376				
100 H_2O	aq			-76.259				
200 H_2O	aq			-76.293				
400 H_2O	aq			-76.332				

Table 34(4) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity
CADMIUM

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$CdBr_2$	in 500 H_2O	aq			-76.344				
	800 H_2O	aq			-76.370				
	1,000 H_2O	aq			-76.376				
	2,000 H_2O	aq			-76.373				
	5,000 H_2O	aq			-76.336				
	10,000 H_2O	aq			-76.309				
	20,000 H_2O	aq			-76.277				
	50,000 H_2O	aq			-76.250				
	100,000 H_2O	aq			-76.239				
	500,000 H_2O	aq			-76.233				
	∞ H_2O	aq			-76.24				
$CdBr_2 \cdot 4H_2O$		c	344.279		-356.73	-298.287		75.6	
$CdBr_3^-$	std. state, m = 1	aq	352.127			-97.4			
CdBrOH		c	209.316		-108.7				
CdI^+	std. state, m = 1	aq	237.304		-33.7	-33.8		10.3	
CdI_2		c	366.209	-48.52	-48.6	-48.13	4.565	38.5	19.11
	std. state m = 1	aq			-44.52	-43.20		35.7	
	undissoc.; std. state, m = 1	aq				-48.1			

Table 34(5) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity
CADMIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
CdI_2 in 400 H_2O	aq			-47.325				
500 H_2O	aq			-47.202				
800 H_2O	aq			-46.980				
1,000 H_2O	aq			-46.875				
2,000 H_2O	aq			-46.530				
5,000 H_2O	aq			-46.090				
10,000 H_2O	aq			-45.705				
20,000 H_2O	aq			-45.412				
50,000 H_2O	aq			-45.067				
100,000 H_2O	aq			-44.867				
500,000 H_2O	aq			-44.620				
∞ H_2O	aq			-44.52				
in CH_3OH				-55.8				
in C_2H_5OH				-53.5				
CdI_3^- std. state, m = 1	aq	493.113			-62.0			
CdI_4^{2-} std. state, m = 1	aq	620.018		-81.7	-75.5		78.	
$Cd(IO_3)_2$	c	462.205			-90.13			
std. state, m = 1	aq			-123.9	-79.7		39.1	
CdIOH	c	256.312		-89.8				
CdS	c	144.464		-38.7	-37.4		15.5	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 34(6) CADMIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$CdSO_4$	c	208.462	-220.720	-223.06	-196.65	4.354	29.407	23.80
std. state, m = 1	aq			-235.46	-196.51		-12.7	
in 15 H_2O	aq			-232.37				
20 H_2O	aq			-232.87				
30 H_2O	aq			-233.27				
50 H_2O	aq			-233.49				
75 H_2O	aq			-233.64				
100 H_2O	aq			-233.72				
150 H_2O	aq			-233.82				
200 H_2O	aq			-233.88				
400 H_2O	aq			-234.040				
500 H_2O	aq			-234.094				
800 H_2O	aq			-234.198				
1,000 H_2O	aq			-234.344				
2,000 H_2O	aq			-234.398				
3,000 H_2O	aq			-234.493				
5,000 H_2O	aq			-234.626				
7,000 H_2O	aq			-234.716				
10,000 H_2O	aq			-234.806				
20,000 H_2O	aq			-234.972				
50,000 H_2O	aq			-235.148				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 34(7) CADMIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$CdSO_4$ 100,000 H_2O	aq			-235.250				
500,000 H_2O	aq			-235.388				
∞ H_2O	aq			-235.46				
$CdSO_4 \cdot H_2O$	c	226.477	-292.087	-296.26	-255.46	5.582	36.814	32.16
$CdSO_4 \cdot 8/3H_2O$	c	256.502	-406.960	-413.33	-350.224	8.497	54.883	50.97
CdS_2O_6 in 800 H_2O	aq	272.524		-304.2				
$CdSO_4 \cdot 2\frac{1}{2}H_2SO_4$	c	453.655		-769.6				
$CdSO_4 \cdot 2Cd(OH)_2$	c	501.291			-429.6			
$2CdSO_4 \cdot Cd(OH)_2$	c	563.338			-515.8			
CdSe	c	191.36						
$CdSeO_3$	c	239.358		-137.5	-119.0		34.0	
std. state, m = 1	aq			-139.8	-106.9		-14.4	
$CdSeO_4$	c	255.358		-151.3	-127.1		39.3	
std. state, m = 1	aq			-161.3	-124.0		-4.6	
in 1200 H_2O	aq			-162.6				
$CdSeO_4 \cdot H_2O$	c	273.373		-225.2				
CdTe	c	240.00		-22.1	-22.0		24.	
CdN_3^+ std. state, m = 1	aq	154.420			62.6			
$Cd(N_3)_2$	c	196.440		108.				
std. state, m = 1	aq			113.38	147.9		34.1	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 34(8) CADMIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Cd(N_3)_2$ undissoc.; std. state, m = 1	aq				144.5			
$Cd(N_3)_3^-$ std. state, m = 1	aq	238.460			226.8			
$Cd(N_3)_4^{2-}$ std. state, m = 1	aq	280.480			309.5			
Cd_3N_2	c	365.312		38.7				
$CdNO_2^+$ std. state, m = 1	aq	158.406			-30.7			
$Cd(NO_3)_2$	c	236.410		-109.06				
std. state, m = 1	aq			-117.26	-71.76		52.5	
in 2.5 H_2O	aq			-111.69				
3.0 H_2O	aq			-112.37				
3.5 H_2O	aq			-112.97				
4.0 H_2O	aq			-113.47				
4.5 H_2O	aq			-113.87				
5.0 H_2O	aq			-114.19				
6 H_2O	aq			-114.77				
7 H_2O	aq			-115.10				
8 H_2O	aq			-115.40				
9 H_2O	aq			-115.63				
10 H_2O	aq			-115.80				
12 H_2O	aq			-116.06				
15 H_2O	aq			-116.29				

Table 34(9) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity
CADMIUM

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Cd(NO_3)_2$ in 20 H_2O	aq			-116.486				
25 H_2O	aq			-116.673				
50 H_2O	aq			-116.725				
100 H_2O	aq			-116.783				
200 H_2O	aq			-116.814				
400 H_2O	aq			-116.84				
500 H_2O	aq			-116.846				
1,000 H_2O	aq			-116.864				
2,000 H_2O	aq			-116.874				
5,000 H_2O	aq			-116.887				
10,000 H_2O	aq			-116.896				
∞ H_2O	aq			-117.26				
$Cd(NO_3)_2 \cdot 2H_2O$	c	272.440		-252.30				
$Cd(NO_3)_2 \cdot 4H_2O$	c	308.471		-394.11				
$Cd(NH_3)^{2+}$ std. state, m = 1	aq	129.431			-28.4			
$Cd(NH_2)_2$	c	144.445		-13.8				
$Cd(N_2H_4)^{2+}$ std. state, m = 1	aq	144.445			8.9			
$Cd(NH_3)_2^{2+}$ std. state, m = 1	aq	146.461		-63.6	-38.0		34.6	
$Cd(N_2H_4)_2^{2+}$ std. state, m = 1	aq	176.491			39.3			

Table 34(10) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CADMIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Cd(NH_3)_4^{2+}$ std. state, m = 1	aq	180.522		-107.6	-54.1		80.4	
$Cd(N_2H_4)_3^{2+}$ std. state, m = 1	aq	208.536			69.4			
$Cd(N_2H_4)_4^{2+}$ std. state, m = 1	aq	240.581			98.5			
$Cd(NH_3)(NO_3)_2$	aq	253.440		-139.3				
$Cd(NH_3)_2(NO_3)_2$	aq	270.471		-161.9				
$Cd(NH_3)_3(NO_3)_2$	aq	287.502		-184.4				
$Cd(NH_3)_4(NO_3)_2$	aq	304.532		-207.0				
$Cd(NH_3)_5(NO_3)_2$	aq	321.563		-229.6				
$Cd(NH_3)_6(NO_3)_2$	aq	338.593		-252.2				
$CdCl_2 \cdot NH_3$	c	200.337		-124.				
$CdCl_2 \cdot 2NH_3$	c	217.367		-152.0	-106.1		51.	
$CdCl_2 \cdot 4NH_3$	c	251.428		-195.4	-116.2		79.	
$CdCl_2 \cdot 6NH_3$	c	285.490		-237.9	-126.2		109.2	
$CdCl_2 \cdot 10NH_3$	c	353.612		-310.8				
$CdCl_2 \cdot NH_4Cl \cdot \frac{1}{2}H_2O$	c	245.805		-207.6				
$CdCl_2 \cdot 4NH_4Cl$	c	397.272		-395.2				
$CdBr_2 \cdot NH_3$	c	289.249		-103.3				
$CdBr_2 \cdot 2NH_3$	c	306.279		-131.5				
$CdBr_2 \cdot 6NH_3$	c	374.402		-218.4				

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Table 34(11) — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — CADMIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$CdBr_2 \cdot 12NH_3$	c	476.585		-328.9				
$CdBr_2 \cdot NH_4Br \frac{1}{2} H_2O$	c	379.173		-172.1				
$CdI_2 \cdot 2NH_3$	c	400.270		-104.0				
$CdI_2 \cdot 6NH_3$	c	468.392		-173.0				
$CdI_2 \cdot NH_4I \frac{1}{2} H_2O$	c	520.159		-134.2				
$(NH_4)_2Cd_2(SO_4)_3$	c	549.062				17.280	116.09	94.0
Cd_3P_2	c	399.148		-27.4				
$CdP_2O_7^{2-}$ std. state, m = 1	aq	286.343			-489.1			
$Cd_3(PO_4)_2$	c	527.143			-587.1			
$CdAs_2$	c	262.243		-4.2				
Cd_3As_2	c	487.043		-10.0				
$Cd_3(AsO_4)_2$	c	615.038			-410.2			
CdSb	c	234.15		-3.44	-3.11		22.2	
Cd_3Sb_2	c	580.70		-13.9				
$CdCO_3$	c	172.409		-179.4	-160.0		22.1	
CdC_2O_4	c	200.420		-218.1				
std. state, m = 1	aq			-215.3	-179.6		-6.6	
undissoc.; std. state, m = 1	aq	200.420			-185.1			
$CdC_2O_4 \cdot 3H_2O$	c	254.466			-360.4			

Table 34(12) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

CADMIUM

Substance				ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description		State	Formula Weight	0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$Cd(C_2O_4)_2^{2-}$	std. state, m = 1	aq	288.440			-348.6			
$Cd_2C_2O_4^{2+}$	std. state, m = 1	aq	312.820			-205.6			
$Cd(CH_3)_2$		liq	142.470		15.2	33.2		48.25	31.55
		g			24.27	35.09		72.4	
$Cd(CHO_2)^+$	formate; std. state, m = 1	aq	157.418			-104.2			
$Cd(CHO_2)_2$	formate; std. state, m = 1	aq	202.436		-221.56	-186.23		26.	
	undissoc.; std. state, m = 1	aq	202.436			-188.8			
$Cd(CH_3CO_2)^+$	acetate; std. state, m = 1	aq	171.445			-109.2			
$Cd(CHO_2)_3^-$	formate; std. state, m = 1	aq	247.454			-272.8			
$Cd(CHO_2)_4^{2-}$	formate; std. state, m = 1	aq	292.472			-356.			
$Cd(CH_3CO_2)_2$	acetate; std. state m = 1	aq	230.490		-250.46	-195.12		23.9	
	undissoc.; std. state, m = 1	aq				-198.0			
$Cd(CH_3CO_2)_3^-$	acetate; std. state m = 1	aq	289.535			-286.4			
$Cd(CH_3CO_2)_4^{2-}$	acetate; std. state, m = 1	aq	348.580			-374.6			
$CdCN^+$	std. state, m = 1	aq	138.418			15.4			

Table 34(13) Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity
CADMIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Cd(CN)_2$	c	164.436		38.8				
std. state, m = 1	aq			53.9	63.9		27.5	
undissoc.; std. state, m = 1	aq				49.7			
in 600 H_2O	aq			40.4				
$Cd(CN)_3^-$ std. state, m = 1	aq	190.454			84.8			
$Cd(CN)_4^{2-}$ std. state, m = 1	aq	216.471		102.3	121.3		77.	
$Cd(ONC)_2$ cadmium fulminate	c	196.435		90.				
$2Cd(CN)_2 \cdot CdO \cdot 5H_2O$	c	547.348		-358.6				
$Cd(NH_2CH_3)^{2+}$ std. state, m = 1	aq	143.458			-17.4			
$Cd[NH_2CH_2CH_2NH_2]^{2+}$	aq	172.499		-38.5				
$Cd(NH_2CH_3)_2^{2+}$ std. state, m = 1	aq	174.515		-58.7	-15.2		40.0	
$Cd(NH_2CH_3)_3^{2+}$ std. state, m = 1	aq	205.573			-11.8			
$Cd(NH_2CH_3)_4^{2+}$ std. state, m = 1	aq	236.631		-98.9	-7.7		84.5	
$Cd[NH_2CH_2CH_2NH_2]_2^{2+}$	aq	-232.599		-58.2				
$Cd[NH_2CH_2CH_2NH_2]_3^{2+}$	aq	292.698		-77.8				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 34(14) CADMIUM

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Cd(NH_2CH_2COO)^+$ std. state, m = 1	aq	186.460			-87.4			
$Cd(NH_2CH_2COO)_2$ undissoc.; std. state, m = 1	aq	260.519			-157.2			
$Cd[NH_2CH_2CH_2NH_2]_3Cl_2$	c	363.604		-167.82				
	aq			-156.26				
$Cd[NH_2CH_2CH_2NH_2]_3Br_2$	c	452.516		-147.93				
	aq			-135.01				
$Cd(CNS)^+$ std. state, m = 1	aq	170.482			1.8			
$Cd(CNS)_2$	c	228.564		12.43				
std. state, m = 1	aq			18.40	25.76		51.4	
undissoc.; std. state, m = 1	aq				23.2			
$Cd(CNS)_3^-$ std. state, m = 1	aq	286.646			45.3			
$[Cd((NH_2)_2CS)_3]^{2+}$	aq	340.761		-81.5				
$Cd((NH_2)_2CS)_3(NO_3)_2$	aq	464.771		-180.6				
$CdSiO_3$	c	188.484		-284.20	-264.20		23.3	21.17
$2CdI_2 \cdot PbI_2$	c	1193.416		-128.0				
$Cd(BO_2)_2$	c	198.020			-354.87			

APPENDIX

The order in which the tables of Series I of National Bureau of Standards Circular 500 are revised follows the Standard Order of Arrangement. However it has been necessary to evaluate the data on certain additional substances in order to complete the calculations for the tables given in this part. The values obtained for some of these compounds are given in the following Table B.

Table B — Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity — BASIC AUXILIARY COMPOUNDS

Substance: Formula and Description	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Ag	c	107.870	0	0	0		10.20	6.07
Ag^+ std. state, m = 1	aq			25.234	18.433		17.40	
Ag_2O	c	231.7394		-7.42	-2.68		29.0	
AgCl	c	143.323		-30.370	-26.244		23.0	
AgBr	c	187.779		-23.99	-23.16		25.6	
AgI	c	234.7744		-14.78	-15.82		27.6	13.58
Hg	liq	200.59		0	0		18.17	
Hg_2Cl_2	c	472.086		-63.39	-50.377		46.0	
Hg_2Br_2	c	560.998			-43.278			
Hg_2I_2	c	654.989			-26.53			
Hg_2SO_4	c	497.242		-177.61	-149.589		47.96	31.54
Na	c	22.9898	0	0	0	1.54	12.24	6.75
Na^+ std. state, m = 1	aq			-57.39	-62.593		14.1	11.1
NaOH	c	39.9972		-101.72				
std. state, m = 1	aq			-112.36	-100.189		11.5	-24.4
K	c	39.102	0	0	0	1.695	15.34	7.07
K^+ std. state, m = 1	aq			-60.32	-67.70		24.5	5.2
KOH	c	56.1094		-101.52				
std. state, m = 1	aq			-115.29	-105.30		21.9	-30.3

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Bi	Bismuth	22	103
Br	Bromine	11	31
C	Carbon	23	106
Cd	Cadmium	34	248
Cl	Chlorine	10	24
F	Fluorine	9	21
Ga	Gallium	30	218
Ge	Germanium	25	177
H	Hydrogen	2	12
He	Helium	3	15
I	Iodine	12	36
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Kr	Krypton	6	18
N	Nitrogen	18	61
Ne	Neon	4	16
O	Oxygen	1	11
P	Phosphorus	19	84
Pb	Lead	27	187
Po	Polonium	17	60
Rn	Radon	8	20
S	Sulfur	14	43
Sb	Antimony	21	99
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Si	Silicon	24	171
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